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MATHÉMATIQUES

SUR LES REPRÉSENTATIONS MONOMIALES ET QUELQUES CRITÈRES POUR QU'UN GROUPE SOIT NON-SIMPLE

Par P. DUBUQUE

(Présenté par O. J. Schmidt, de l'Académie, le 8. II. 1939)

Dans le présent article on donne quelques théorèmes sur le normalisateur d'un élément dans un groupe fini et quelques applications de ces théorèmes à la déduction de nouveaux critères pour qu'un groupe soit non-simple. En certaines parties les résultats obtenus complètent et précisent les énoncés qui ont été formulés par l'auteur dans sa Note «Sur le normalisateur d'un élément dans un groupe fini» dont une communication préliminaire a été publiée dans les Comptes Rendus de l'Académie des Sciences de l'URSS (1). Pour obtenir les théorèmes fondamentaux on s'appuie essentiellement sur l'invariance d'une expression qui se trouve souvent dans la théorie des représentations monomiales des groupes. Notamment, dans plusieurs cas il est très utile d'appliquer la proposition suivante dont on vérifie la justesse par un calcul très simple:

Théorème 1. *Soit* $\mathfrak{G}$ *un groupe fini arbitraire,* $\mathfrak{H}$ *— un sous-groupe de* $\mathfrak{G}$ *de sorte que*

$$\mathfrak{G} = \mathfrak{H} + \mathfrak{H}G_2 + \ldots + \mathfrak{H}G_n \qquad (1)$$

et A *— un certain élément du groupe* $\mathfrak{G}$. *Soit*

$$\mathfrak{H}G_{\alpha_1}, \mathfrak{H}G_{\alpha_2}, \ldots, \mathfrak{H}G_{\alpha_k} \qquad (2)$$

l'ensemble des systèmes du développement (1) *qui se transforment l'un en l'autre en ordre cyclique quand on multiplie (à droite) par* A.

Soit $G_{\alpha_i}A = H_iG_{\alpha_{i+1}}$, *où tous les* H_i *sont des éléments du groupe* $\mathfrak{H}$ $(i = 1,2,\ldots,k;\ G_{\alpha_{k+1}} = G_{\alpha_1})$. *Si le produit* $H_1, H_2 \ldots H_k$ *appartient au centre du groupe* $\mathfrak{H}$, *il est invariant par rapport au choix du système des résidus dans les systèmes* (2).

En s'appuyant sur le théorème 1, on obtient le résultat suivant.

Théorème 2. *Soit* A *un élément d'ordre* p^k *du groupe* $\mathfrak{G}$ (p *étant un nombre premier impair*). *Si chaque élément du normalisateur de l'élément* A^{p^i} $(0 < i < k)$ *conjugué à* A^z *est de la forme* A^{mz}, *où* $m \equiv 1 \pmod{p}$, *le rapport des ordres des normalisateurs des éléments* $A^{p^{i+1}}$ *et* A^{p^i} *n'est pas divisible par* p^2.

Pour obtenir le théorème 2 on profite des méthodes et des notations de la théorie des quasi-normalisateurs (2).

Pour le cas $\lambda_i \neq k-i$ la démonstration s'appuie sur la proposition complémentaire suivante.

Lemme. *Si les conditions du théorème 2 sont vérifiées et si d'ailleurs* $\lambda_i \neq k-i$, *alors le rapport des ordres des quasi-normalisateurs* $\mathfrak{N}_{A^{p^i}}^{(\lambda_i)}$ *et* $\mathfrak{N}_{A^{p^{i+1}}}^{(\lambda_i)}$ *est congru à 1 suivant le module* p^i.

La démonstration du lemme est assez compliquée et s'appuie sur l'application du théorème 1. Si $\lambda_i = k-i$, le théorème est facile à démontrer directement. Pour le cas où $i \neq 0$, le théorème 2 précise l'un des résultats obtenus par l'auteur dans son article précédemment cité (1). En appliquant un nombre suffisant de fois le théorème 2, on peut obtenir enfin la proposition suivante.

Théorème 3. *Soit A un élément d'ordre* p^k *d'un groupe* $\mathfrak{G}$ (*p étant un nombre premier impair*). *Si chaque élément du normalisateur d'un élément* A^{p^i} $(i \neq 0)$ *conjugué à l'élément* A^z *est de la forme* A^{mz}, *où* $m \equiv 1 \pmod{p}$, *alors le rapport des ordres des normalisateurs des éléments* $A^{p^{i+1}}$ *et A n'est pas divisible par* p^{i+2}.

En posant $i = k-2$ nous arriverons au cas particulier du théorème 3 qui est le plus important. Les théorèmes 2 et 3 sont encore valables pour le cas où $p=2$, si l'on ajoute la condition supplémentaire que l'élément $A^{2^{k-2}}$ du quatrième ordre ne soit pas conjugué à son élément inverse (3). Par exemple, un théorème analogue au théorème 2 peut être formulé de la manière suivante.

Théorème 4. *Soit A un élément d'ordre* 2^k *d'un groupe* $\mathfrak{G}$. *Si chaque élément du normalisateur de l'élément* A^{2^i} $(i \neq 0)$ *conjugué à une puissance de A est encore une puissance de A et si l'élément* $A^{2^{k-2}}$ *n'est pas conjugué à son élément inverse, le rapport des normalisateurs des éléments* $A^{2^{i+1}}$ *et* A^{2^i} *n'est pas divisible par 4.*

On modifie de même le théorème 3. Signalons maintenant une proposition de caractère plus spécial.

Théorème 5. *Soit A un élément d'ordre* p^k (*p étant un nombre premier*) *d'un groupe* $\mathfrak{G}$ *tel que A n'est conjugué à aucune de ses puissances. Si chaque élément du normalisateur de l'élément* $A^{p^{k-2}}$ *conjugué à* A^z *est de la forme* A^{mz}, *où* $m \equiv 1 \pmod{p}$, *alors le rapport des ordres des normalisateurs des éléments* $A^{p^{k-1}}$ *et A n'est pas divisible par p.*

Passons aux critères pour qu'un groupe soit non-simple. Indiquons d'abord le résultat suivant.

Théorème 6. *Soit A un élément d'ordre* p^k (*p étant un nombre premier*) *d'un groupe* $\mathfrak{G}$ *tel que A n'est conjugué à aucune de ses puissances. Supposons que chaque élément du normalisateur de l'élément* $A^{p^{k-2}}$ *conjugué à* A^z *est de la forme* A^{mz}, *où* $m \equiv 1 \pmod{p}$. *Si l'ordre du normalisateur de l'élément A n'est pas divisible par* p^{2k}, *le groupe* $\mathfrak{G}$ *possède un diviseur normal. L'ordre de ce diviseur normal est un multiple du plus grand diviseur de l'ordre du groupe* $\mathfrak{G}$ *qui est premier avec p.*

Pour démontrer le théorème 6 il suffit d'appliquer un critère pour qu'un groupe soit non-simple, critère trouvé par W. Turkin dans le second des articles cités (2) et complété par l'auteur (3), et s'appuyer d'ailleurs sur le théorème 5.

Pour obtenir les résultats qui suivent nous avons besoin d'élargir d'abord un peu le domaine d'applicabilité des théorèmes suivants démontrés dans l'article de Turkin et Dubuque «Sur la structure des groupes simples» (4).

Théorème A. Soit $\mathfrak{P}$ un sous-groupe abélien d'ordre p^α d'un certain groupe $\mathfrak{G}$ d'ordre $p^\beta n$ (*p* étant un nombre premier impair, *n* n'est pas

divisible par p). Soit A un élément du sous-groupe $\mathfrak{P}$ d'ordre p^k et supposons d'ailleurs que chaque élément de $\mathfrak{P}$ conjugué à A^z est égal à A^{mz}, où $m \equiv 1 \pmod{p}$. Si l'ordre du normalisateur de l'élément $A^{p^{k-1}}$ n'est pas divisible par $p^{\alpha+k}$, le groupe $\mathfrak{G}$ possède un diviseur normal dont l'ordre est divisible par n.

Théorème B. Soit $\mathfrak{P}$ un sous-groupe abélien d'ordre 2^α d'un certain groupe $\mathfrak{G}$ d'ordre $2^\beta n$ (n — impair). Soit A un élément d'ordre 2^k du sous-groupe $\mathfrak{P}$ et supposons d'ailleurs que chaque élément de $\mathfrak{P}$ conjugué à une puissance de A est encore une puissance de A. Si l'élément $A^{2^{k-2}}$ n'est pas conjugué à son élément inverse et si l'ordre du normalisateur de l'élément $A^{2^{k-1}}$ n'est pas divisible par $2^{k+\alpha}$, le groupe $\mathfrak{G}$ possède un diviseur normal dont l'ordre est divisible par n.

Enonçons les propositions suivantes plus générales.

Théorème 7*. *Soit A un élément d'ordre p^k appartenant au centre du sous-groupe $\mathfrak{P}$ d'ordre p^α d'un certain groupe $\mathfrak{G}$ (p étant un nombre premier impair). Supposons que l'élément $A^{p^{k-1}}$ n'appartient pas à la commutante du groupe $\mathfrak{P}$. Si chaque élément du groupe $\mathfrak{P}$ conjugué à A^z est de la forme A^{mz}, ou $m \equiv 1 \pmod{p}$, et si l'ordre du normalisateur de l'élément $A^{p^{k-1}}$ n'est pas divisible par $p^{\alpha+k}$, le groupe $\mathfrak{G}$ possède un diviseur normal. L'ordre de ce diviseur normal est un multiple du plus grand diviseur de l'ordre du groupe $\mathfrak{G}$ premier avec p.*

Théorème 8. *Soit A un élément d'ordre 2^k appartenant au centre du sous-groupe $\mathfrak{P}$ d'ordre 2^α d'un certain groupe $\mathfrak{G}$. Supposons que l'élément $A^{2^{k-1}}$ n'appartient pas à la commutante du groupe $\mathfrak{P}$. Si chaque élément du groupe $\mathfrak{P}$ conjugué à une puissance de A est encore une puissance de A, l'élément $A^{2^{k-2}}$ n'est pas conjugué à son élément inverse et l'ordre du normalisateur de l'élément $A^{2^{k-1}}$ n'est pas divisible par $p^{\alpha+k}$, alors le groupe $\mathfrak{G}$ possède un diviseur normal. L'ordre de ce diviseur normal est un multiple du plus grand diviseur impair de l'ordre du groupe $\mathfrak{G}$.*

Pour démontrer les théorèmes 7 et 8 il suffit de faire quelques remarques supplémentaires à la démonstration des théorèmes A et B et, en particulier, d'appliquer le théorème 1. En s'appuyant sur le théorème 7 et en appliquant le théorème 3 pour le cas où $i = k-2$, nous obtenons le critère suivant pour qu'un groupe soit non-simple.

Théorème 9. *Soit A un élément d'ordre p^k du groupe $\mathfrak{G}$ (p étant un nombre premier impair). Supposons que l'élément $A^{p^{k-1}}$ n'appartient pas à la commutante du p sous-groupe de Syloff du normalisateur de l'élément A. Si chaque élément du normalisateur de l'élément $A^{p^{k-2}}$ conjugué à A^z est de la forme A^{mz}, où $m \equiv 1 \pmod{p}$, alors le groupe $\mathfrak{G}$ possède un diviseur normal. L'ordre de ce diviseur normal est un multiple du plus grand diviseur de l'ordre du groupe $\mathfrak{G}$ premier avec p.*

Si $k \leqslant 2$, le normalisateur de l'élément $A^{p^{k-2}}$ doit dans les conditions du théorème être remplacé par le normalisateur de l'élément $A^{p^{k-1}}$.

Pour le cas où $p = 2$ on obtient le critère suivant:

Théorème 10. *Soit A un élément d'ordre 2^k du groupe $\mathfrak{G}$. Supposons que l'élément $A^{2^{k-1}}$ n'appartient pas à la commutante d'un sous-groupe de Syloff du normalisateur de l'élément A dont l'ordre est une puissance de 2. Si chaque élément du normalisateur de l'élément $A^{2^{k-2}}$ conjugué à une puissance de A est encore une puissance de A, et si l'élément $A^{2^{k-2}}$ n'est pas conjugué à son élément inverse, alors le groupe $\mathfrak{G}$ possède un diviseur*

* Théorème 7 peut être obtenu comme cas particulier d'une proposition plus générale, sur laquelle une note préliminaire a été publiée par W. Turkin (5).

normal. L'ordre de ce diviseur normal est un multiple du plus grand diviseur impair de l'ordre du groupe $\mathfrak{G}$.

Comme conséquence des théorèmes cités on a le critère suivant pour les groupes non-simples.

Théorème 11. *Soit A un élément d'ordre p d'un groupe* $\mathfrak{G}$ (*p étant un nombre premier*). *Si A n'est conjugué à aucun des éléments du p sous-groupe de Syloff* $\mathfrak{P}$ *de son normalisateur et s'il n'appartient pas à la commutante de* $\mathfrak{P}$, *le groupe* $\mathfrak{G}$ *possède un diviseur normal. L'ordre de ce diviseur normal est un multiple du plus grand diviseur de l'ordre du groupe* $\mathfrak{G}$ *premier avec p.*

En ce qui concerne l'existence du diviseur normal, sans parler de son ordre, le théorème 11 contient comme cas particulier le théorème suivant bien connu de Burnside ([6]). Si le groupe $\mathfrak{G}$ d'ordre g possède un sous-groupe de Syloff d'ordre p^α qui appartient au centre de son normalisateur, le groupe $\mathfrak{G}$ possède un diviseur normal d'ordre $\frac{g}{p^\alpha}$.

Le théorème 11 est de même une généralisation du théorème suivant démontré par W. Turkin dans son article «Ein neues Kriterium der Einfachheit einer endlichen Gruppe» ([7]).

Soit $\mathfrak{G}$ un groupe d'ordre $p^\alpha m$ (p étant un nombre premier, m n'est pas divisible par p). Supposons que le $\mathfrak{P}$ sous-groupe de Syloff d'ordre p^α du groupe $\mathfrak{G}$ est abélien. Si $\mathfrak{P}$ contient un élément appartenant au centre du normalisateur du groupe $\mathfrak{P}$, le groupe $\mathfrak{G}$ possède un diviseur normal dont l'ordre est un multiple de m.

Enfin, on a comme cas particulier du théorème 11 le résultat suivant obtenu par l'auteur antérieurement ([1]).

Soit A un élément d'ordre p d'un groupe $\mathfrak{G}$ (p étant un nombre premier). Si le p sous-groupe de Syloff du normalisateur de l'élément A est un groupe abélien et si aucun de ses éléments n'est conjugué à A, le groupe $\mathfrak{G}$ possède un diviseur normal. L'ordre de ce diviseur normal est un multiple du plus grand diviseur de l'ordre du groupe $\mathfrak{G}$ premier avec p.

En concluant, faisons encore une remarque: tandis que les théorèmes 9 et 10 s'appuient essentiellement et en plusieurs points sur la théorie des quasi-normalisateurs, il n'en est pas de même pour le théorème 11 qui peut être obtenu indépendemment de cette théorie. En effet, en s'appuyant sur la méthode des représentations monomiales des groupes, on peut démontrer la proposition suivante.

Théorème 12. *Soit A un élément d'ordre* p^k *d'un groupe* $\mathfrak{G}$ (*p étant un nombre premier*). *Soit* $\mathfrak{P}$ *le p sous-groupe de Syloff du normalisateur de l'élément* $A^{p^{k-1}}$. *Si l'élément A n'appartient pas à la commutante du groupe* $\mathfrak{P}$ *et si chaque élément du normalisateur de l'élément* $A^{p^{k-1}}$ *conjugué à* A^z *est de la forme* A^{mz}, *où* $m \equiv 1 \pmod{p}$, *alors le groupe* $\mathfrak{G}$ *possède un diviseur normal. L'ordre de ce diviseur normal est un multiple du plus grand diviseur de l'ordre du groupe* $\mathfrak{G}$ *premier avec p.*

Il est facile à voir qu'en posant, dans les conditions du théorème 12, $k=1$ nous arriverons au théorème 11.

Institut de Mathématiques.
Université de Moscou.

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MATHÉMATIQUES

QUELQUES NOUVELLES APPLICATIONS DE LA THÉORIE DES RÉSOLVENTES AUX PROBLÈMES LIMITES DE LA THÉORIE DU POTENTIEL

Par W. KOUPRADZE

(Présenté par S. L. Soboleff, de l'Académie, le 2. II. 1939)

Dans les équations intégrales de Fredholm que l'on trouve dans la théorie du potentiel il arrive souvent que le paramètre λ est égal à une valeur caractéristique. Si la valeur caractéristique est un pôle simple de la résolvente, on sait qu'il est possible au moyen de raisonnements simples d'arriver à la résolution du problème limite. Plusieurs problèmes de la théorie du potentiel amènent, en effet, au cas où la valeur caractéristique est un pôle simple de la résolvente (par exemple le problème extérieur de Dirichlet pour l'équation de Laplace). Il est possible que c'est par cette raison-là que le cas où la valeur caractéristique est un pôle multiple de la résolvente n'a pas, à ce qu'il paraît, encore été étudié. Et cependant ce cas lui aussi peut présenter un intérêt pour les applications; c'est pourquoi nous indiquons dans la suite une méthode pour résoudre dans ce cas les problèmes limites.

Pour fixer les idées nous nous bornons à la considération des problèmes de Dirichlet et Neuman pour l'équation

$$\Delta u + k^2 u \equiv \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} + k^2 u = 0 \qquad (1)$$

que l'on rencontre dans plusieurs problèmes de la physique mathématique.

Introduisons les notations suivantes: F est une surface fermée et bornée vérifiant les conditions bien connues de Liapounoff; P, Q—les points hors de F; M, N—les points sur F; r—la distance entre deux points; n_M, n_N—les normales extérieures à la surface F aux points M et N; k—une constante positive;

$$\frac{1}{2\pi i}\frac{\partial}{\partial n_N}\left(\frac{e^{-ikr(M,N)}}{r(M,N)}\right) = K(M,N);$$

$$\frac{1}{2\pi i}\frac{\partial}{\partial n_M}\left(\frac{e^{-ikr(MN)}}{r(M,N)}\right) = K(N,M);$$

$\mu(N)$, $\nu(N)$—des fonction continues du point N;

$(VP) = \frac{1}{2\pi i} \int_F \nu(N) \frac{e^{-ikr(N,P)}}{r(NP)} ds_N$—le potentiel de la simple couche de densité $\nu(N)$;

$W(P) = \frac{1}{2\pi i} \int_F \mu(N) \frac{\partial}{\partial n_N} \left[\frac{e^{-ikr(N,P)}}{r(N,P)} \right] ds_N$—le potentiel de la double couche de densité $\mu(N)$;

$V_i(P)$, $V_e(P)$, $W_i(P)$, $W_e(P)$—les valeurs limites de $V(P)$ et $W(P)$ quand le point P s'approche vers un point frontière sur F en restant respectivement à l'intérieur de F ou hors de F; $f(N)$, $\varphi(N)$—des fonctions continues et finies définies sur F.

Les problèmes intérieur et extérieur de Dirichlet D_i et D_e, si l'on cherche leurs solutions dans la forme de potentiels de double couche, amènent aux équations intégrales [1]:

$$\mu(M) - \int_F \mu(N) K(M,N) ds_N = -f(M), \qquad (D_i)$$

$$\mu(M) + \int_F \mu(N) K(M,N) ds_N = f(M). \qquad (D_e)$$

Les problèmes de Neuman N_i et N_e, si l'on cherche leurs solutions dans la forme de potentiels de simple couche, amènent aux équations:

$$\nu(M) + \int_F \nu(N) K(N,M) ds_N = \varphi(M), \qquad (N_i)$$

$$\nu(M) - \int_F \nu(N) K(N,M) ds_N = -\varphi(M). \qquad (N_e)$$

Les équations intégrales homogènes correspondant à (D_i), (D_e), (N_i), (N_e) seront désignées par (D_i^0), (D_e^0), (N_i^0), (N_e^0).

Dans l'étude de ces équations intégrales la valeur du coefficient k dans l'équation (1) joue un rôle essentiel; on a quelques théorèmes [1], qui donnent une solution complète des problèmes extérieurs de Dirichlet et Neuman, si k n'a pas certaines valeurs exceptionnelles. Dans le livre «Les problèmes fondamentaux de la théorie mathématique de diffraction» [1] j'ai considéré les cas où k coïncide avec les fréquences des problèmes D_i^0 et N_i^0 et j'ai donné une méthode pour résoudre les problèmes dans ces cas; d'ailleurs, j'ai reqrqué que cette méthode a une portée générale; cependant, il est facile à voir qu'elle n'est applicable qu'au cas où $\lambda = \pm 1$ est un pôle simple de la résolvente correspondante *. Dans le cas d'un pôle multiple la solution est donnée par la théorie générale des noyaux canoniques. L'étude de ce cas est précisément l'objet du présent article. Rappelons les résultats fondamentaux de la théorie des noyaux canoniques.

Soit $\lambda = +1$ un pôle d'ordre p de la résolvente de l'equation (D_e);

$$\Gamma(M,N;\lambda) = \sum_{i=1}^{p} \frac{A_i(M,N)}{(1-\lambda)^{p-i+1}} + \sum_{i=p+1}^{\infty} A_i(M,N)(1-\lambda)^i. \qquad (2)$$

* Dans mon livre cité on trouvera d'ailleurs quelques autres inexactitudes qu'il faudrait corriger ou préciser (étude d'un système infini, théorèmes sur l'équivalence).

Les coefficients $A_i(M,N)$ $(i=1, 2, \dots, p, p+1)$ vérifient les équations:

$$A_1(M,N)+\int K(M,R)\,A_1(R,N)\,ds_R=0=A_1(M,N)+$$
$$+\int A_1(M,R)\,K(R,N)\,ds_R;$$
$$A_j(M,N)+\int K(M,R)\,A_j(R,N)\,ds_R=-\sum_{i=1}^{j-1}A_i(M,N)=$$
$$=A_j(M,N)+\int A_j(M,R)\,K(R,N)\,ds_R \quad (j=2,3,\dots,p); \tag{3}$$
$$A_{p+1}(M,N)+\int K(M,R)\,A_{p+1}(R,N)\,ds_R=$$
$$=K(M,N)-\sum_{i=1}^{p}A_i(M,N)=A_{p+1}(M,N)+$$
$$+\int A_{p+1}(M,R)\,K(R,N)\,ds_R.$$

Les $A_i(M,N)\,(i\leqslant p)$ sont linéairement indépendants et ne sont pas identiquement nuls. Considérons le système des fonctions fondamentales de notre équation $\mu_{i,j}^{(1)}$, $\nu_{i,j}^{(1)}$. Elles satisfont aux conditions:

$$\mu_{i_1}^{(s)}(M)+\int K(M,R)\,\mu_{i_1}^{(s)}(R)\,ds_R=0 \quad \left(\begin{array}{l} s=0, \quad i=1,2,\dots,q_1 \\ s=1, \quad i=q_1+1,\dots,q_2 \\ \dots\dots\dots\dots\dots \\ s=p-1,\ i=q_{p-1}+1,\dots,n \end{array}\right)$$

$$\mu_{i,j_s}^{(s)}(M)+\int K(M,R)\mu_{i,j_s}^{(s)}(R)\,ds_R=$$
$$=-\sum_{k=1}^{j_s-1}\mu_{ik}^{(s)}(M) \quad \left(\begin{array}{l} 1\leqslant i\leqslant q_1, \quad s=0, \quad j_s=1,2,3,\dots,p_0 \\ q_1+1\leqslant i\leqslant q_2, \quad s=1, \quad j_s=1,2,3,\dots,p_1 \\ q_2+1\leqslant i\leqslant q_3, \quad s=2, \quad j_s=1,2,3,\dots,p_2 \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ q_{p-1}+1\leqslant i\leqslant n, \quad s=p-1, \quad j_s=1=p_{p-1} \end{array}\right) \tag{4}$$
$$\nu_{i1}^{(s)}(N)+\int \nu_{i1}^{(s)}(R)\,K(R,N)\,ds_R=0$$
$$\nu_{ij_s}^{(s)}(N)+\int \nu_{ij_s}^{(s)}(R)\,K(R,N)\,ds_R=-\sum_{k=1}^{j_s-1}\nu_{ik}^{(s)}(N) \tag{5}$$

pour les mêmes valeurs des indices; d'ailleurs, on a

$$p_0=p>p_1>p_2\dots\geqslant 1.$$

D'ailleurs, les fonctions principales vérifient les équations suivantes de biorthogonalité:

$$\int_F \mu_{ij_s}^{(s)}(N)\,\nu_{ri_k}^{(k)}(N)\,ds_N=\begin{matrix}1, si\ i=r,\ s=k,\ i_s+i_k=p_s+1.\\ 0\end{matrix}$$

Dans le «Cours d'Analyse» de E. Goursat (2) ce système est indiqué dans une Note à la page 85, § 579. Pour passer des notations de Goursat à celles que nous utilisons il faut poser

$$\varphi^i=\mu_{j,i}^{(1)}, \quad \psi_i=\sum_{l=1}^{s-i+1}\nu_{j,l}^{(1)}.$$

Evidemment, $\mu_{i,1}^{(1)}$ et $\nu_{i,1}^{(s)}$ sont des fonctions fondamentales de notre équation.

Au moyen des fonctions principales le noyau canonique $k(M,N) = \sum_{i=1}^{\infty} A_i(M,N)$ peut être présenté dans la forme:

$$k(M,N) = \sum_{r=1}^{p} \sum_{i=q_{r-1}+1}^{q_r} \sum_{l=1}^{p-r} \mu_{i,l}^{(r)} \, n_{i,\,p-r-l+1}^{(r)} \tag{6}$$

ou dans la forme:

$$k(M,N) = \sum_{r=1}^{p} \sum_{i=q_{r-1}+1}^{q_r} \sum_{l=1}^{p-r} \nu_{i,l}^{(r)} \, m_{i,p-r-l+1}^{(r)} \tag{7}$$

Les fonctions $m_{ij}^{(s)}$ et $n_{ij}^{(s)}$ s'expriment linéairement au moyen des fonctions $\mu(M)$ et $\nu(N)$.

Un calcul prouve que $m_{ij}^{(s)}$ et $n_{ij}^{(s)}$ sont linéairement indépendants.

$c_i^{(k)}$ étant proprement choisi, il existe le potentiel de double couche

$$\int_F \mu^*(R) \frac{\partial}{\partial n_R} \left[\frac{e^{-ikr(P,R)}}{r(PR)} \right] ds_R \tag{8}$$

qui admet sur la frontière (quand on s'approche de l'extérieur) la valeur

$$f(M) - \sum_{i=1}^{q_1} c_i^0 \mu_{ip}^0 - \sum_{i=q_1+1}^{q_1} c_i^{(1)} \mu_{ip_1}^{(1)} - \ldots - \sum_{i=q_{p-1}+1}^{\infty} c_i^{(p-1)} \mu_{i1}^{(p-1)}. \tag{9}$$

Introduisons les notations:

$$W^*(P) = \frac{1}{2\pi i} \int_F \mu^*(R) \frac{\partial}{\partial n_R} \left[\frac{e^{-ikr(PR)}}{r(PR)} \right] ds_M = \int_F \mu^*(R) \, K(P,R) \, ds_R;$$
$$W_{ij_s}^{(s)}(P) = \frac{1}{2\pi i} \int_F \mu_{ij_s}^{(s)}(M) \frac{\partial}{\partial n_R} \left[\frac{e^{-ikr(PR)}}{r(PR)} \right] ds_R = \int_F \mu_{ij_s}^{(s)}(R) \, K(P,R) \, ds_R. \tag{10}$$

Il suit de (4) en tenant compte de la propriété des sauts des potentiels de double couche que, quand le point P tout en restant hors de F s'approche d'un point M sur F (1), on obtient facilement:

$$\mu_{ij_s-1}^{(s)}(M) = \lim_{P \to M} \left[W_{i,j_s-1}^{(s)} - W_{i,j_s}^{(s)} \right] = \lim_{P \to M} W_{ij_s-1}^{*s}(P). \tag{11}$$

De (3_3) du potentiel de double couche nous obtenons:

$$W(P,N) = \frac{1}{2\pi i} \int_F A_{p+1}(R,N) \frac{\partial}{\partial n_R} \left[\frac{e^{-ikr(PR)}}{r(PR)} \right] ds_R$$
$$\lim_{P \to M} W(P,N) = K(M,N) - k(M,N). \tag{12}$$

En tenant compte de (11) et (6) on peut écrire $k(M,N)$ dans la forme:

$$k(M,N) = \sum_{i=1}^{q_{p-1}} \sum_{j=1}^{p_s-1} \mu_{ij}^{(s)} n_{ip_s-j+1}^{(s)} + \sum_{i=1}^{n} \mu_{ip_s}^{(s)} \nu_{i1}^{(s)} =$$
$$= \lim_{P \to M} \sum_{i=1}^{q_{p-1}} \sum_{j=1}^{p_s-1} W_{ij}^{*s}(P) \, n_{ip_s-j+1}^{(s)}(N) + \sum_{i=1}^{n} \mu_{ip_s}^{(s)} \nu_{i1}^{(s)}(N).$$

En tenant compte de ce que les fonctions $\nu_{i1}^{(s)}(N)$ $(i=1, 2, \ldots, n)$ sont linéairement indépendantes, on choisit pour N des valeurs N_k de telle manière que le déterminant

$$\| \nu_{il}(N_k) \| \neq 0 \tag{13}$$

et on introduit la notation

$$\sum_{i=1}^{q_{p-1}} \sum_{j=1}^{p_s-1} W_{ij}^{*s}(P)\, n_{ip_s-j+1}(N_k) = W_k^{**}(P) \qquad (k=1, 2, 3, \ldots, n).$$

Il suit alors de (12) que l'on a

$$\lim_{P\to M} \left\{ K(P, N_k) - W(P, N_k) - W_k^{**}(P) \right\} = \lim_{P\to M} W_k(P) =$$

$$= \sum_{i=1}^{n} \nu_{i1}^{(s)}(N_k)\, \mu_{ip_s}^{(s)}(M) \qquad (k=1, 2, \ldots, n). \tag{14}$$

En résolvant (14) relativement à $\mu_{ip_s}^{(s)}(M)$ nous obtenons

$$\mu_{ip_s}^{(s)}(M) = \lim_{P\to M} \sum_{k=1}^{n} a_k^{(s)} \overline{W}_k(P) \begin{pmatrix} s=0, 1, 2 \ \ldots, p-1 \\ p_s = p, p_1, p_2, \ldots, 1 \end{pmatrix}$$

En comparant avec (9) on voit que le potentiel de double couche

$$W^*(P) + \sum_{i=1}^{n} \sum_{k=1}^{n} c_i^{(s)}\, a_k^{(s)}\, \overline{W}_k(P) \tag{15}$$

prend la valeur $f(M)$ quand le point P tend vers le point frontière M extérieurement.

D'autre part, (15) est évidemment une solution de l'équation $\Delta u + k^2 u = 0$ et vérifie la condition de rayonnement à l'infini; donc, (15) est la solution unique du problème extérieur de Dirichlet à valeurs limites données quand le paramètre k est une valeur caractéristique.

Indiquons comme second exemple la solution du problème extérieur de Neuman. Pour ne pas répéter plusieurs formules analogues à celles qui ont déjà été citées, nous n'introduirons pas de nouvelles notations pour les fonctions fondamentales et principales. Cependant il faut tenir compte de ce que maintenant il s'agit des équations (D_i^0) et (N_e^0) dont les résolventes ont $\lambda = -1$ pour pôle du p-ième ordre.

L'équation

$$\nu^*(N) - \int_F \nu^*(M)\, K(M, N)\, ds_N = -\varphi(N) + \sum_{i=1}^{n} c_i^{(s)}\, \nu_{ip_s}^{(s)}(N) \tag{16}$$

a une solution, si les constantes $c_i^{(s)}$ sont définies par les conditions

$$c_i^{(s)} = -\int_F \varphi(N)\, \mu_{i1}^{(s)}(N)\, ds_N \begin{pmatrix} s=0, 1, 2, \ldots, p-1 \\ i=1, 2, 3, \ldots, n \end{pmatrix} \tag{17}$$

Ainsi le potentiel de simple couche

$$\int_F \nu^*(R)\, \frac{e^{-ikr(PR)}}{r(PR)}\, ds_R \tag{18}$$

donne une solution de l'équation $\Delta u + k^2 u = 0$ telle que sa dérivée normale en tendant extérieurement vers la frontière prend la valeur

$$-\varphi(N) + \sum_{i=1}^{n} c_i^{(s)}\, \nu_{ip_s}^{(s)}(N). \tag{19}$$

Introduisons les notations:

$$\left.\begin{aligned} V^*(P) &= \frac{1}{2\pi i}\int_F \nu^*(R)\,\frac{e^{-ikr(PR)}}{r(PR)}\,ds_R, \\ V^{(s)}_{ij_s}(P) &= \frac{1}{2\pi i}\int_F \nu^{(s)}_{ij_s}(R)\,\frac{e^{-ikr(PR)}}{r(PR)}\,ds_R. \end{aligned}\right\} \tag{20}$$

Il suit de (5)*, en tenant compte des propriétés du saut de la dérivée normale du potentiel de simple couche, que si le point tend extérieurement vers la frontière, on peut écrire

$$\nu^{(s)}_{ij_s-1}(N) = \lim_{P\to N}\frac{\partial}{\partial n}\left\{V^{(s)}_{i.j_s-1}(P) - V^{(s)}_{i.j_s}(P)\right\} = \lim_{P\to N}\frac{\partial V^{*s}_{ij_s-1}}{\partial n}. \tag{21}$$

Il suit de (3_3) que la valeur limite (extérieure) de la dérivée normale du potentiel de simple couche

$$V(PM) = \frac{1}{2\pi i}\int_F A_{p+1}(R, M)\,\frac{e^{-ikr(PR)}}{r(PR)}\,ds_R$$

dépendant du paramètre M, quand P tend extérieurement vers N, est

$$K(N, M) - k(N, M),$$

$$\lim_{P\to N}\frac{\partial}{\partial n}V(P, M) = K(N, M) - k(N, M). \tag{22}$$

Le noyau canonique $k(N, M)$ est de la forme

$$k(N, M) = \sum_{i=1}^{q_{p-1}}\sum_{j=1}^{p_s-1}\nu^{(s)}_{ij}(N)\,m^{(s)}_{i,p_s-j+1}(M) + \sum_{i=1}^{n}\nu^{(s)}_{ip_s}(N)\,\mu^{(s)}_{i1}(M).$$

En vertu de (22) $k(N, M)$ peut être écrit dans la forme

$$k(N, M) = \lim\sum_{i=1}^{q_{p-1}}\sum_{j=1}^{p_s-1}\frac{\partial}{\partial n}V^{*s}_{ij}(P)\,m^{(s)}_{ip_s-j+1}(M) + \sum_{i=1}^{n}\nu^{(s)}_{ip_s}(N)\,\mu^{(s)}_{i1}(M).$$

Les fonctions $\mu^{(s)}_{i1}(M)$ étant linéairement indépendantes, on peut donner à M des valeurs M_k telles que l'on ait

$$\|\mu^{(s)}_{i1}(M_k)\| \neq 0 \qquad (k = 1, 2, \ldots, n).$$

Introduisons la notation:

$$\sum_{i=1}^{q_{p-1}}\sum_{j=1}^{p_s-1}V^{*s}_{ij}(P)\,m^{(s)}_{p_s-j+1}(M_k) = V^{**}_k(P) \quad (k = 1, 2, 3, \ldots, n).$$

Il suit de (20) que l'on a

$$\lim_{P\to N}\frac{\partial}{\partial n}\left\{\frac{e^{-ikr(P,M_k)}}{r(P, M_k)} - V(P, M_k) - V^{**}_k(P)\right\} = \sum_{i=1}^{n}\nu^{(s)}_{ip_s}(N)\,\mu^{(s)}_{i1}(M_k).$$

Dans les parenthèses du premier membre de ce système linéaire on a évidemment la solution (par rapport à P) de l'équation $\Delta u + k^2 u = 0$; désignons-le par $\overline{V}_k(P)$; en résolvant le système, on aura:

$$\nu^{(s)}_{ip_s}(N) = \lim_{P\to N}\frac{\partial}{\partial n}\sum_{k=1}^{n}b^{(s)}_k\overline{V}_k(P)\begin{pmatrix} s = 0, 1, 2, \ldots; p-1 \\ p_s = p, p_1, p_2, \ldots 1 \end{pmatrix}.$$

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* Dans les formules (5) et (3) on a maintenant le signe — devant l'intégrale et les noyaux sont transposés.

Il est maintenant évident que la dérivée normale du potentiel de simple couche

$$V^*(P) - \sum_{i=1}^{n}\sum_{k=1}^{n} l_i^{(s)} b_k^{(s)} \overline{V}_k(P) \qquad (23)$$

a pour valeur $\varphi(N)$, quand P tend extérieurement vers la frontière.

D'autre part, (23) est la solution de l'équation $\Delta u + k^2 u = 0$ qui vérifie la condition de rayonnement à l'infini.

Donc, (23) est une solution et d'ailleurs la solution unique du problème extérieur de Neuman, les valeurs frontières $\varphi(N)$ étant données et k étant une valeur caractéristique.

Institut de Mathématiques de Tbilissi.
Section Géorgienne de
l'Académie des Sciences de l'URSS.

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MECHANICS

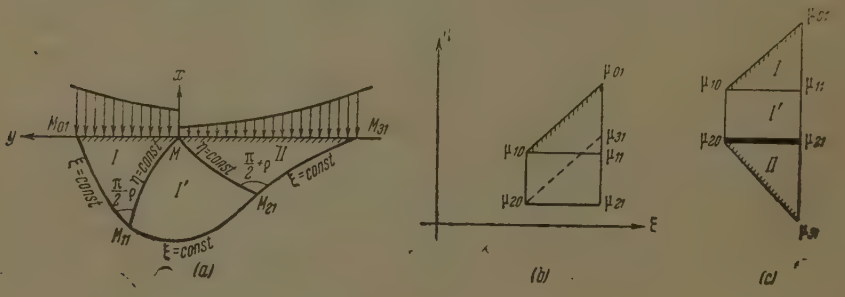
ON A PROBLEM OF THE THEORY OF EARTH PRESSURE

By W. SOKOLOVSKY

(Communicated by I. M. Vinogradow, Member of the Academy, 13. II. 1939)

In our paper published in the C. R. Acad. Sci. URSS (1) we established the basic equations and some relations necessary for the solution of problems of the theory of earth pressure *. In the same paper was given the solution of the problem of earth pressure on a supporting wall.

Let us now discuss another problem, which we shall call the generalized Prandtl's problem.



Along the portion $M_{01}M$ is given a normal load and it is necessary to determine the least normal load preventing the protrusion of the earth along MM_{31}. For the particular case of a constant load in the absence of mass forces this problem was solved by Prandtl and Reissner.

Let us consider the case when within the portion MM_{01} $\sigma'_x(y) > 0$, which corresponds to a monotonous increase of load along the axis y (Fig. *a*).

First let us consider the case of the absence of mass forces ($\overline{X} = \overline{Y} = 0$). The characteristics in this case will be $\xi = \text{const}$ and $\eta = \text{const}$.

The plane (ξ, η) consists of two superimposed sheets.

* The numeration of formulae mentioned in this article refers to the formulae of our paper (1).

On the upper sheet we construct the straight line (14′) in the form of $\mu_{01}\mu_{10}$, along which we have (15) (Fig. *b*).

Solving the Cauchy problem for the equation (6), we find x, y in the triangle $\mu_{01}\mu_{11}\mu_{10}$ and therefore we obtain the values of x, y along $\mu_{10}\mu_{11}$.

On the lower sheet we construct the straight line (14″). The points of its intersection with the characteristics $\xi = \text{const}$ passing through μ_{10} and μ_{01} we denote by μ_{20} and μ_{31}. To the portion of the characteristic $\mu_{10}\mu_{20}$ on the plane (x, y) corresponds a point M with the co-ordinates (0,0). Therefore along $\mu_{10}\mu_{20}$ we assume $x = 0$, $y = 0$.

Solving the Goursat problem for the equations (6), we determine x, y in the rectangle $\mu_{10}\mu_{20}\mu_{21}\mu_{11}$ on the upper sheet according to their values along $\mu_{10}\mu_{11}$ and $\mu_{10}\mu_{20}$. Let us join both sheets along $\mu_{20}\mu_{21}$. Now on the lower sheet along $\mu_{20}\mu_{21}$ x, y are known and along $\mu_{20}\mu_{31}$ $x = 0$.

Solving the mixed problem for the equations (6), we find

$$x = x(\xi, \eta), \quad y = y(\xi, \eta)$$

in the triangle $\mu_{20}\mu_{21}\mu_{31}$. Inverting these functions, we shall obtain

$$\xi = \xi(x, y) \quad \eta = \eta(x, y).$$

Substituting $\xi(0, y)$ into (14″), we find

$$\sigma(y) = e^{\operatorname{tg}\rho\left(2\xi - \frac{3\pi}{2} + \rho\right)}$$

and then, by (13″), we obtain

$$\sigma_x(y) = \sigma(y)(1 - \sin\rho) - \frac{K}{\sin\rho}.$$

The value of σ_x at the point M on the right (denoted by $[\sigma_x]_{M-}$) may be determined from the value of σ_x at the same point M on the left (denoted by $[\sigma_x]_{M+}$). To this end we determine from (13′) and (14′) $\xi_{\mu_{10}}$ in the following form:

$$\xi_{\mu_{10}} = \frac{\operatorname{ctg}\rho}{2} \ln\left(\frac{[\sigma_x]_{M+} + \frac{K}{\sin\rho}}{1 + \sin\rho}\right) + \frac{\pi}{4} - \frac{\rho}{2}.$$

According to formulae (13″) and (14″), we find

$$\xi_{\mu_{20}} = \frac{\operatorname{ctg}\rho}{2} \ln\left(\frac{[\sigma_x]_{M-} + \frac{K}{\sin\rho}}{1 - \sin\rho}\right) + \frac{3\pi}{4} - \frac{\rho}{2}.$$

Using the equality

$$\xi_{\mu_{20}} = \xi_{\mu_{10}},$$

we obtain the stress

$$[\sigma_x]_{M-} = \frac{1 - \sin\rho}{1 + \sin\rho}\left([\sigma_x]_{M+} + \frac{K}{\sin\rho}\right)e^{-\pi\operatorname{tg}\rho} - \frac{K}{\sin\rho},$$

depending on the value of the stress σ_x at the point M on the left only; the same stress remains also in the case of the presence of mass forces.

Let us further consider the case of the presence of mass forces. The characteristics in this case will be $\alpha = \text{const}$ and $\beta = \text{const}$. The plane (α, β) consists of two superimposed sheets.

In the choice of α and β we have some freedom which we shall later make use of. On the upper sheet let us choose α and β so that along $M_{01}M$ they should coincide with (14′):

$$\alpha = \alpha(y) = \xi(y), \quad \beta = -\frac{\pi}{2} + \rho + \alpha.$$

The image of this curve on the upper sheet (α, β) will be the straight line $\mu_{01}\mu_{10}$, along which we shall have (21)*.

Solving the Cauchy problem for the equations (5), we determine x, y and ξ, η in the triangle $\mu_{01}\mu_{11}\mu_{10}$ and, consequently, we obtain the values of x, y and ξ, η along $\mu_{10}\mu_{11}$ as a function of α.

On the lower sheet we construct the straight line

$$\beta = -\frac{3\pi}{2} + \rho + \alpha$$

the points of intersection of which with the characteristics $\alpha = \text{const}$ passing through μ_{10} and μ_{01} we denote as μ_{20} and μ_{31}. Along the portion of the characteristic $\mu_{10}\mu_{20}$ we assume $\beta = \eta$ and, since to the portion $\mu_{10}\mu_{20}$ on the plane (x, y) there corresponds one point M with the co-ordinates (0,0), along $\mu_{10}\mu_{20}$ we have:

$$x = 0, \quad y = 0, \quad \eta = \beta, \quad \xi = \xi(0).$$

Solving the Goursat problem for the equations (5), we determine x, y and ξ, η in the rectangle $\mu_{10}\mu_{20}\mu_{21}\mu_{11}$ on the upper sheet according to their values along $\mu_{10}\mu_{11}$ and $\mu_{10}\mu_{20}$. Let us join both sheets along $\mu_{20}\mu_{21}$. Now x, y and ξ, η on the lower sheet are known along $\mu_{20}\mu_{21}$, and along $\mu_{20}\mu_{31}$

$$x = 0, \quad \eta = -\frac{3\pi}{2} + \rho + \xi.$$

Solving the mixed problem for the equations (5), we obtain

$$x = x(\alpha, \beta), \quad y = y(\alpha, \beta), \quad \xi = \xi(\alpha, \beta), \quad \eta = \eta(\alpha, \beta)$$

in the triangle $\mu_{20}\mu_{21}\mu_{31}$. Inverting the first two of the obtained functions, we shall have:

$$\alpha = \alpha(x, y), \quad \beta = \beta(x, y),$$

and then we obtain:

$$\xi[\alpha(x, y), \beta(x, y)] = \xi_1(x, y), \quad \eta[\alpha(x, y), \beta(x, y)] = \eta_1(x, y).$$

Substituting $\xi_1(0, y)$ in (14″), we find

$$\sigma(y) = e^{\operatorname{tg}\rho\left(2\xi_1 - \frac{3\pi}{2} + \rho\right)}$$

and further by (13″) we obtain

$$\sigma_x(y) = \sigma(y)(1 - \sin\rho) - \frac{K}{\sin\rho}.$$

In the same way the cases $\sigma'_x(y) < 0$, $\sigma_x = \text{const}$ are dealt with, as well as the case when the given load consists of several portions, within each of which it varies monotonously.

In the latter case the planes (ξ, η) and (α, β) will be manysheeted.

Stekloff Mathematical Institute.
Academy of Sciences of the USSR.

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* The constructions on the plane (α, β) coincide with the constructions on the plane (ξ, η) shown on Fig. *b* and *c*.

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THEORY OF ELASTICITY

ON THE DEFORMATIONS OF NATURALLY TWISTED BARS

By P. RIZ

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We consider here the deformations of naturally twisted bars, i. e. such bars, the cross-sections of which are turned with respect to each other in the undeformed state. The axis of the bar we suppose to be a straight line passing through the centres of gravity of the cross-sections. In the case, when the linear dimensions of the cross-section are small in comparison with the length of the bar (the so-called thin bars), the deformations of such a bar were investigated on the base of Kirchhoff's general theory of thin bars. This theory, however, practically postulates the independence of the torsion from the tension and the independence of the torque deformations from the natural twist. The first postulate is manifestly refuted by the experiment indicating the phenomenon of untwisting of the bar at its tension. This phenomenon was for the first time investigated by Wood and Perring (1), but the additional hypotheses formulated in their paper contradict to the general equations of the theory of elasticity. They assume, namely, that the tangential stresses in the deformed cross-section are such, as if the bar were untwisted by a certain torque couple, and that the normal stresses remain the same as in the case of pure tension.

We do not make the assumption that the linear dimensions of the cross-section are small in comparison with the length of the bar, so that in this sense our results are more general than the results following from Kirchhoff's theory. Neither shall we use any hypothetical considerations on the distribution of stresses.

In the present note, representing the first part of our paper, we consider the tension of a naturally twisted bar; next we shall consider the deformations of torsion and flexure of naturally twisted bars and also the deformations of twisted bars with narrowing profiles.

a) General Relations. The origin of the system of co-ordinates is chosen in the centre of gravity on the one of the cross-sections, the axes x and y are directed along the principal axes of this cross-section; the z-axis coincides with the axis of the bar. The rotation of the cross-sections with respect to a certain initial cross-section is determined by the angle $\alpha(z)$.

Consider, besides, a local system of co-ordinates ξ, η, ζ. The axes ξ and η coincide with the principal axes of each cross-section and the ζ-axis coincides with the axis of the bar.

It is easy to obtain the following relations:

$$\left.\begin{aligned} \xi &= x\cos\alpha - y\sin\alpha, \\ \eta &= x\sin\alpha + y\cos\alpha, \\ \zeta &= z. \end{aligned}\right\} \qquad (1)$$

$$\left.\begin{aligned} \frac{\partial}{\partial x} &= \cos\alpha\,\frac{\partial}{\partial\xi} + \sin\alpha\,\frac{\partial}{\partial\eta}, \\ \frac{\partial}{\partial y} &= -\sin\alpha\,\frac{\partial}{\partial\xi} + \cos\alpha\,\frac{\partial}{\partial\eta}, \\ \frac{\partial}{\partial z} &= \frac{\partial}{\partial\zeta} + \frac{d\alpha}{dz}\left(\xi\,\frac{\partial}{\partial\eta} - \eta\,\frac{\partial}{\partial\xi}\right). \end{aligned}\right\} \qquad (2)$$

The equation of the lateral surface will be written as $f(\xi, \eta) = 0$, or

$$f(x\cos\alpha - y\sin\alpha,\ x\sin\alpha + y\cos\alpha) = 0.$$

We suppose that $\alpha(z) = \Theta z$. The quantity Θ, called the natural torsion, we shall suppose to be a small constant quantity. Consider now the problem of solving the equations of the theory of elasticity up to the terms of the order Θ^2 carrying out all calculations with the same degree of precision.

b) Tension by a Force Applied to the End of the Bar. Consider the deformation of the bar under the action of tension stresses distributed on the butt and statically equivalent to a force P parallel to the axis of the bar and applied at the centre of gravity of the butt cross-section.

Assume the following expressions for the stresses:

$$\sigma_{zz} = p + p\Theta\sigma_{zz}^{(1)}; \quad \sigma_{xx} = p\Theta\sigma_{xx}^{(1)}; \quad \sigma_{yy} = p\Theta\sigma_{yy}^{(1)}; \quad \sigma_{xy} = p\Theta\sigma_{xy}^{(1)};$$

$$\sigma_{xz} = p\Theta\sigma_{xz}^{(1)}; \quad \sigma_{yz} = p\Theta\sigma_{yz}^{(1)}; \quad \left(p = \frac{P}{S}\right),$$

where $\sigma_{zz}^{(1)}$ etc. are the unknown functions of ξ, η, ζ. For supplementary stresses we obtain the following equilibrium equations:

$$L_1^{(1)} = 0, \quad L_2^{(1)} = 0, \quad L_3^{(1)} = 0,$$

where

$$L_1^{(1)} = \frac{\partial\sigma_{xx}^{(1)}}{\partial\xi} + \frac{\partial\sigma_{xy}^{(1)}}{\partial\eta} + \frac{\partial\sigma_{xz}^{(1)}}{\partial\zeta},$$

. . . . . .

and the boundary conditions expressing the absence of stresses on the lateral surface:

$$M_1^{(1)} = 0, \quad M_2^{(1)} = 0, \quad M_3^{(1)} + (\xi f_\eta' - \eta f_\xi') = 0,$$

where

$$M_1^{(1)} = \sigma_{xx}^{(1)} f_\xi' + \sigma_{xy}^{(1)} f_\eta' \ldots \quad M_3^{(1)} = \sigma_{xz}^{(1)} f_\xi' + \sigma_{yz}^{(1)} f_\eta'.$$

We shall satisfy all these conditions as well as the compatibility conditions, if we put:

$$\left.\begin{aligned} \sigma_{xz}^{(1)} &= \eta + k(\varphi_\xi' - \eta), \\ \sigma_{yz}^{(1)} &= -\xi + k(\varphi_\eta' + \xi), \\ \sigma_{xx}^{(1)} &= \sigma_{yy}^{(1)} = \sigma_{xy}^{(1)} = \sigma_{zz}^{(1)} = 0. \end{aligned}\right\} \qquad (3)$$

Here $\varphi(\xi, \eta)$ denotes the torque function for the profile $f(\xi, \eta) = 0$. The constant k we find from the condition that the torque moment in the cross-section must be zero. After simple calculations we obtain $k = \frac{I_p}{T}$, where I_p is the polar moment of inertia and T—the geometrical torque stiffness.

For the displacements we find that, besides the usual displacements caused by the tension, a certain untwisting of the bar takes place. The supplementary displacements are as follows:

$$\left.\begin{aligned} u &= -\frac{p\Theta}{\mu}\left(\frac{I_p}{T}-1\right) yz, \\ v &= \frac{p\Theta}{\mu}\left(\frac{I_p}{T}-1\right) xz, \\ w &= \frac{p\Theta}{\mu}\frac{I_p}{T}\varphi(\xi, \eta). \end{aligned}\right\} \tag{4}$$

(μ — modulus of the shift).

For the torque angle per unit length τ we find:

$$\tau = \frac{p\Theta}{\mu}\left(\frac{I_p}{T}-1\right). \tag{5}$$

The formula of Wood and Perring in our denotations reads $\tau = \frac{p\Theta}{\mu}\frac{I_x - I_y}{T}$; for thin cross-sections, for which $I_x \gg I_y$, this formula is near to our formula, but if $I_y > I_x$, it gives an absurd result (a further twisting instead of untwisting).

c) Tension by Mass Forces of Constant Intensity. Denoting the intensity of mass forces by ρ, let us assume the following expressions for the stresses:

$$\begin{aligned} \sigma_{zz} &= \rho z + \rho\Theta\sigma_{zz}^{(1)}, & \sigma_{xy} &= \rho\Theta\sigma_{xy}^{(1)}, \\ \sigma_{xx} &= \rho\Theta\sigma_{xx}^{(1)}, & \sigma_{xz} &= \rho\Theta\sigma_{xz}^{(1)}, \\ \sigma_{yy} &= \rho\Theta\sigma_{yy}^{(1)}, & \sigma_{yz} &= \rho\Theta\sigma_{yz}^{(1)}. \end{aligned}$$

The equilibrium equations are:

$$L_1^{(1)} = 0, \quad L_2^{(1)} = 0, \quad L_3^{(1)} = 0.$$

The boundary conditions:

$$M_1^{(1)} = 0, \quad M_2^{(1)} = 0, \quad M_3^{(1)} + \zeta_n(\xi f'_\eta - \eta f'_\xi) = 0.$$

We shall satisfy the equilibrium equations and the third boundary condition, if we put

$$\left.\begin{aligned} \sigma_{xz}^{(1)} &= \eta\zeta + k\zeta(\varphi'_\xi - \eta), & \sigma_{xx}^{(1)} &= \frac{\partial^2 F}{\partial\eta^2} - \xi\eta - k(\varphi - \xi\eta), \\ \sigma_{yz}^{(1)} &= -\xi\zeta + k\zeta(\varphi'_\eta + \xi), & \sigma_{yy}^{(1)} &= \frac{\partial^2 F}{\partial\xi^2} + \xi\eta - k(\varphi + \xi\eta), \\ \sigma_{zz}^{(1)} &= 2k\varphi\nu + \nabla^2 F\nu + C + A\xi + B\eta, & \sigma_{xy}^{(1)} &= -\frac{\partial^2 F}{\partial\xi\partial\eta}. \end{aligned}\right\} \tag{6}$$

The constant k we determine from the same considerations as above and find for it the same value $k = \frac{I_p}{T}$. A, B and C we determine from the conditions

$$\int\int \sigma_{zz}^{(1)}\, d\xi\, d\eta = 0, \quad \int\int \xi\sigma_{zz}^{(1)}\, d\xi\, d\eta = \int\int \eta\sigma_{zz}^{(1)}\, d\xi\, d\eta = 0.$$

From the compatibility conditions and the first two boundary conditions we find that $F(\xi, \eta)$ is a biharmonic function satisfying the boundary conditions:

$$\left[\frac{\partial^2 F}{\partial \eta^2} - \xi\eta - k(\varphi - \xi\eta)\right] f'_\xi - \frac{\partial^2 F}{\partial \xi \partial \eta} f'_\eta = 0,$$
$$-\frac{\partial^2 F}{\partial \xi \partial \eta} f'_\xi + \left[\frac{\partial^2 F}{\partial \xi^2} + \xi\eta - k(\varphi + \xi\eta)\right] f'_\eta = 0.$$

The displacements consist of three kinds: the usual displacements due to tension forces, certain displacements giving a plane deformation and, beside these, the displacements of untwisting. We give only these last:

$$\left.\begin{aligned} u &= -\frac{\rho\Theta}{\mu}\left(\frac{I_p}{T} - 1\right) y \frac{z^2}{2}, \\ v &= \frac{\rho\Theta}{\mu}\left(\frac{I_p}{T} - 1\right) x \frac{z^2}{2}, \\ w &= \frac{\rho\Theta}{\mu}\frac{I_p}{T}\varphi(\xi, \eta) z. \end{aligned}\right\} \tag{7}$$

For the torque angle we obtain:

$$\tau = \frac{\rho\Theta}{\mu}\left(\frac{I_p}{T} - 1\right) z. \tag{8}$$

For some contours of cross-sections the supplementary plane deformation is also easily determined; thus, for the elliptical cross-section with the half-axes a and b:

$$\left.\begin{aligned} F &= \frac{a^2 - b^2}{6}\xi\eta + \frac{a^2 - b^2}{12}\left(1 - \frac{\xi^2}{a^2} - \frac{\eta^2}{b^2}\right)\xi\eta, \\ \sigma_{xx} = \sigma_{yy} = 0, \quad \sigma_{xy} &= \frac{\rho\Theta}{4}(a^2 - b^2)\left(\frac{\xi^2}{a^2} + \frac{\eta^2}{b^2} - 1\right). \end{aligned}\right\} \tag{9}$$

We omit the corresponding displacements.

d) The Case of a Variable Natural Twist (the force being applied at the end). Consider the case when the torque angle of the cross-sections in the unstressed state is given by the law

$$\alpha(z) = \Theta_1 \frac{z^2}{2}.$$

The equilibrium equations and the boundary conditions completely coincide with the conditions of the problem c) and the final results may be obtained from the formulae of the preceding section by replacing $\rho\Theta$ by $\rho\Theta_1$. We can also easily deal with the case when

$$\alpha(z) = \Theta z + \Theta_1 \frac{z^2}{2}.$$

In this case the supplementary stresses and displacements are obtained by superposition of the corresponding values for the problem of constant twist and of the twist $\Theta_1 z$.

We confine ourselves to stating here only the formula for the torque angle:

$$\tau = \frac{p}{\mu}\left(\frac{I_p}{T} - 1\right)(\Theta + \Theta_1 z) = \frac{p}{\mu}\left(\frac{I_p}{T} - 1\right)\frac{d\alpha}{dz}. \tag{10}$$

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PHYSICS

NOTE ON THE SUPERFLUIDITY OF LIQUID HELIUM. II

By J. FRENKEL, Corresponding Member of the Academy

The superfluidity (i. e. extremely small viscosity) of liquid helium II is explained by London (1) and by Tisza (2) on the basis of Einstein's theory of the degeneracy of an ideal Bose gas at low temperatures. According to this theory, the particles of such a gas, below a certain temperature T_0 begin to crowd up into the lowest quantum state, and cease to influence, the viscosity and heat conductivity of the gas which are determined by the behaviour of the remaining particles. As the number of the latter and also their energy decrease with further lowering of the temperature, the viscosity of the system must fall down, tending to zero at $T=0$.

This point of view is open to serious objections. In the first place it seems very unlikely that liquid helium with its relatively high density could be treated as an ideal gas. It is universally accepted now that liquids in the vicinity of their crystallization point can be likened to solids rather than to gases. This view has actually been applied by London to helium in his previous work (3) which opened the way for the very interesting theory of Fröhlich on the nature of the transition from helium II to helium I (4).

The fact that helium remains liquid at $T=0$ under pressure not exceeding 25 atmospheres clearly shows that it cannot be treated as an ordinary liquid with a quasi-crystalline structure, differing from that of the corresponding crystal by a certain degree of disorder. In fact the degree of disorder is measured by the entropy which tends to zero as the temperature of the absolute zero is approached.

Under such conditions it seems reasonable to assume that helium II must be treated as a substance on an average with a regular arrangement of atoms, differing from an ordinary crystal by a distortion (curvature) of the atomic layers, curved surfaces playing the rôle of different crystallographic planes. This type of structure is not unique: it is met with according to Friedel in the case of the smectic phase of a number of liquid crystalline substances. In the latter case it is due, however, to strong lateral attraction of the rod-shaped molecules, while in the case of helium II the curvature of the crystallographic surfaces is a consequence of the violent «rest» motion of the atoms near the temperature of the absolute zero.

From this point of view, the notion of «viscosity» can hardly be applied to helium II. In fact, the viscous flow of an ordinary liquid must be considered as a kind of directed diffusion process, in which the atoms participate individually by a step-wise change of their equilibrium position (5). The connexion between viscosity and diffusion is illustrated by the fact that

their dependence upon the temperature is determined by the same activation energy u (the diffusion coefficient is proportional to $e^{-u/kT}$, while the viscosity coefficient to $e^{u/kT}$). Now it is obvious that the diffusion coefficient of any substance—either liquid or solid—must tend to zero as the temperature is lowered. If therefore the viscosity of helium II were connected with its diffusion coefficient in the usual way, it should tend to infinity at $T=0$ and not to zero, as actually found.

Now it is well known that crystals, in contradistinction to liquids and amorphous bodies in general, exhibit a phenomenon of flow under shearing stress which is essentially different from an ordinary viscous flow (though apparently similar to it), and which is described as a plastic deformation. This plastic flow is usually characterized by a certain «elasticity limit» (i. e. a certain minimum value of the shearing stress which is necessary for its beginning) and is accompanied by a «hardening» of the substance which brings it to a stop, unless the shearing stress is further increased. Recent experiments have shown, however, that single crystals in the virgin state (i. e. before the beginning of the plastic deformation) are extremely «soft», their elasticity limit being hundreds and thousands times smaller than the value technically assigned to the corresponding substance in the polycrystalline state. The investigation of plastic deformation with the help of photoelectric methods ([6]) shows that there is practically no limit to the decrease of the elasticity limit, as the perfection of the crystal is increased. As, however, plastic slipping is accompanied by a distortion of the lattice, it involves a rapid increase of the elasticity limit.

Plastic slipping can take place at the absolute zero of temperature, in contradistinction to viscous flow. It is stopped under such conditions by the process of hardening referred to above. For that reason the ordinary technical plastic flow or «creep» of polycrystalline substances is furthered by an increase of the temperature, in a way similar to ordinary viscous flow (being in fact proportional to $e^{-u'/kT}$ with a value of u', different from that which corresponds to diffusion).

Coming back to helium II, we thus see that its superfluidity can be easily understood if it is assumed: 1) that its elasticity limit is equal to zero and 2) that it is not «hardened» by the process of plastic slipping.

The latter assumption follows directly from the fact that helium II remains «liquid», i. e. plastic, and can be interpreted from the theoretical point of view by the fact that any microscopic distortions of the crystal lattice, which might arise in the process of plastic slipping, are immediately removed by the «quantum» agitation of the atoms (playing the rôle of heat motion in ordinary crystals). It seems natural that this «rest» motion which, in contradistinction to the ordinary heat motion, tends to bring order into the structure of helium II, instead of producing disorder, can also reduce to zero the value of the elasticity limit.

It is not yet possible to state definitely whether helium II has an infinite fluidity from the very beginning (as assumed by Kapitza), or a fluidity which tends to infinity, as the temperature is lowered till zero (according to Keesom and others). Both alternatives are theoretically possible, although the latter seems to be more probable. In fact the increase of resistance to flow with increase of temperature might be considered as the natural consequence of the beginning disorder produced by heat motion and finally resulting in the transition of helium II into helium I which behaves as an ordinary liquid.

On the other hand, it could be easily imagined that the behaviour of helium II with respect to mechanical flow can be likened to the behaviour of supra-

conductive bodies with respect to the flow of electricity, no heat being evolved in either case and, consequently, no resistance to flow being displayed.

We did not attempt hitherto to describe the mechanism of plastic flow in crystals and to explain why this type of flow can take place at a temperature of absolute zero. This question has been treated in a special paper ([7]), where it has been shown that plastic slipping is essentially similar to a process of twinning which is propagated in the form of a wave and which consists in a successive rotation of certain crystallographic planes within a more or less narrow layer of the crystalline substance (the atoms being brought into equivalent, or symmetrical positions). Whatever the exact picture of this process, it is clear that it is a process of organized, collective motion which can be started by a relatively insignificant force, while the process of ordinary viscous flow corresponds to a drift of individual atoms, superimposed upon their chaotic self-diffusion motion in the direction of the applied external force.

Hence it is clear that while the viscous flow of amorphous bodies must stop at low temperatures, the plastic flow of crystalline bodies must persist at the temperature of absolute zero and must give rise to superfluidity in the case of such a substance as helium, where the «rest» motion secures the persistance of regularity in the arrangement of atoms, thus excluding the phenomenon of «hardening» and probably decreasing to zero the value of the elasticity limit.

Physico-Technical Institute.
Leningrad.

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PHYSICS

A NEW METHOD OF MEASURING THE ENERGY OF HARD GAMMA-RAYS

By B. S. DŽELEPOV

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Most of the methods applied in measuring the energy of soft gamma-rays are found to fail when energy exceeds 2—3 MeV. If the latter is more increased, both internal conversion of gamma-rays and photoelectric absorption are negligible. The passage of gamma-rays through matter is accompanied by the Compton effect and by pair-formation. The latter phenomenon plays the principal part for energies higher than 5 MeV and it may naturally be applied in measuring the energies of very hard gamma-rays.

Delsasso, Fowler and Lauritsen (1) determined gamma-ray energy from the sum of the energies of the pair components which they observed in a Wilson chamber, placed in a magnetic field. Subsequent experiments (2) have shown the results thus obtained to be far more accurate than the measurements of the track curvature of electrons, knocked out in the case of Compton effect. In this case, the lines obtained are comparatively narrow, and therefore the above method satisfies the main requirements of spectrography, i. e. it allows to separate the effects due to different gamma-lines. This method, however, requires a powerful gamma-source and a great number of photographs, since the absorption of hard gamma-rays in gas or in a thin plate placed in a chamber is very low.

The method suggested by Alichanov and Kozodaev (3) is far more convenient and simple. These authors have investigated with a magnetic spectrograph the energy distribution of positrons, produced by the internal conversion of gamma-rays with formation of pairs.

Experimental evidence, which is in full agreement with theory, shows that in the case of heavy nuclei the positron spectrum is sharply cut off at the energy of $h\nu - 2m_0c^2$. The position and the magnitude of the drop may be used to determine the energy and the comparative intensity of the corresponding gamma-lines. The chief advantage of this method as against that of Delsasso, Fowler and Lauritsen is that it renders possible the study of separate, most important regions of the spectrum. The defect of this method is that the presence of several gamma-lines results in the formation of a complex positron spectrum, which must be afterwards separated into its components. The drop corresponding to the softer line appears on the background of the spectra due to all the harder lines. Very accurate measurements are necessary to detect and measure these drops. Moreover, two counters used as positron detectors have to be placed one behind the other, which involves

a considerable number of coincidences caused by cosmic rays or by electrons torn out from the counter walls. This circumstance hinders the study of positron spectra when low intensity gamma-sources are present.

The method outlined below is free from these two defects. The main features of this new method are shown in Fig. 1, where A is the source of gamma-rays forming pairs, C_1 and C_2 are the counters. The whole arrangement is placed in a uniform magnetic field perpendicular to the plane of the scheme. The coincidence of discharges occurs, when the electron and the positron of one pair get into different counters. The measurement of the number of coincidences as dependent on the intensity of magnetic field will give a linear spectrum. The lines will appear only when the energies of the electron and the positrons are $\frac{1}{2}(h\nu - 2m_0c^2)$. Thus, the effects due to different gamma-lines are here fully separated.

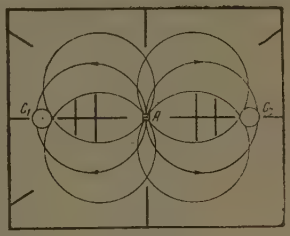

Fig. 1.

At first, it may be thought that, in order to obtain a noticeable number of coincidences, a very powerful gamma-ray source is necessary, since for a coincidence to occur not only the positron, but also the electron must have the appropriate energy and direction of ejection. This latter requirement, however, is found to a great extent to be satisfied automatically.

To begin with, let us assume that both the positron and the electron, created at pair formation, are ejected strictly in the same direction. Then

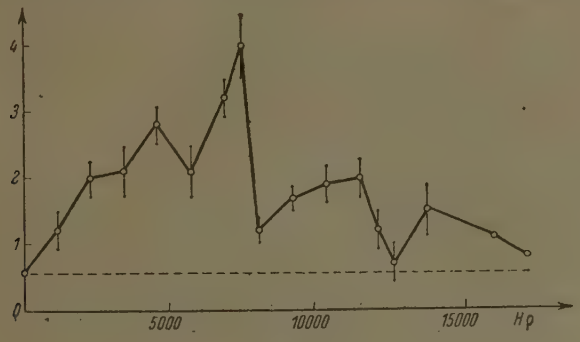

Fig. 2.

if the magnetic field is such that $H\rho$ corresponds to the energy of $\frac{1}{2}(h\nu - 2m_0c^2)$, whenever the positron gets into one of the counters, the electron will inevitably get into another counter, since both have the same energy and the same direction of ejection. In this case, the number of coincidences would be strictly equal to the number of additional discharges occurring in each counter. As a matter of fact, however, the number of coincidences must be smaller, since the positrons and the electrons are not ejected in the same direction. The angle between the directions of ejection of electrons and positrons due to the internal conversion of hard gamma-rays is on the average very small. The theory developed by Uhlenbeck and Rose ([4]), which is in close agreement with experimental data, shows that with a gamma-ray energy of, say, 7 MeV the angle of divergence of one half of the pairs will be less than 31° (quadripole radiation, $E_+ = E_-$). The experimental values of the mean angle of divergence at the formation of a pair in the field of a foreign nucleus are somewhat larger. In the apparatus shown in Fig. 1, however,

a beam is focussed having a divergence of 30° in the vertical plane and of 60° in the horizontal plane. Owing to the great width of the beam, the two particles for a large number of pairs are found to be in the focussed portion of the beam. Moreover, this type of the apparatus permits of using double divergence, thus doubling the number of coincidences. Consequently, if the same beam divergence, an equal radius of trajectory curvature and an equal activity of the source are used, the number of coincidences obtained by the Alichanov and Kozodaev technique and by our method respectively ought to be approximately equal. As, however, in the present method the counters are placed far from each other, the number of spontaneous coincidences is very small, and this makes it possible to investigate much weaker source. For instance, if counters having a cross-section of 1.8×6 cm are arranged vertically at a distance of 18.5 cm, then about 0.5 coincidence per hour will be observed in the absence of a source. So low a background allows to work with sources giving 3—4 coincidences per hour, i. e. emitting only 1—2 pairs per second.

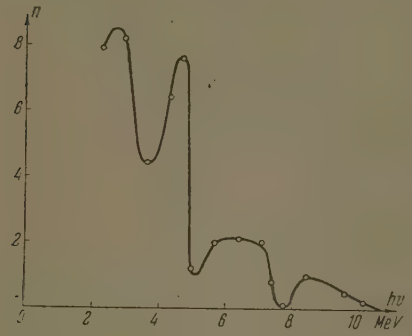

Fig. 3.

The first test of the present technique was made on gamma-rays formed in the case of bombardment of beryllium by alpha-particles. The writer had a comparatively weak source of polonium, of about 4 mC, containing admixtures of RaD and RaE. This made it necessary to enclose the polonium and beryllium in a celluloid layer which absorbed the RaE electrons. The celluloid was in its turn enveloped in lead foil (100—500 μ), in which pairs were formed.

The intensity of gamma-radiation formed by the excited C_6^{12} nuclei was very low, much lower than the limit of intensity necessary for other methods. According to the magnetic field, the number of coincidences varied from 0.5 to 4.0 per hour, spontaneous coincidences being about 0.57 per hour. Three runs of measurements gave approximately the same results. Fig. 2 shows an averaged experimental curve. Near the points a probable statistical error is shown. 317 coincidences were recorded in all. Taking into consideration the variation in the interval of energy, we plotted a curve (Fig. 3) where the presence of 3 gamma-lines of about 2.7, 4.7 and 7.0 MeV may be seen.

Bothe ([5]) supposed that the C_6^{13*} spectrum contains three lines with energies of about 2.7, 4.2 and 6.7 MeV. Further studies showed the first two lines to be due, at least partly, to cascade transition, and the intensities of all the three lines to be approximately equal. The energies of the gamma-rays as obtained in our experiments approach those of Bothe's data, but the intensity ratio proved different. If we take into account the dependence of the probability of pair-formation and of the thickness of the effective layer of lead on energy, but introduce no correction for the variation of the mean angle of divergence with energy, then it may be seen from Fig. 3 that for the last two lines intensities are in the proportions 14 : 1.

The intensity of the first, softest gamma-line (2.7 MeV) may be determined only very roughly, since the conditions for measuring in this region are very unfavourable (a great thickness of the lead layer round the source, the presence of air in the apparatus at a pressure of 100 mm Hg, etc.). For the

line lying near 7 MeV the conditions are the most favourable, and yet it is seen to be less intense than it was found by other investigators.

The above experiments are only a first test of the new technique. A more detailed study of the gamma-spectrum of C_6^{12}* nuclei will be carried on in the near future.

Physico-Technical Institute.
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PHYSIQUE

UNE GERBE DE LOURDES PARTICULES

Par A. JDANOFF

(Présenté par V. G. Chlopine, de l'Académie, le 14. II. 1939)

Ce n'est que dans des cas très rares que l'on réussit à observer la désintégration nucléaire par les rayons cosmiques dans la chambre de Wilson. Il paraît que la méthode des plaques photographiques à couches épaisses, élaborée au cours de plusieurs années à notre Institut ([1],[2],[3],[4]), aboutit à des résultats plus efficaces. Suivant cette méthode on a pu observer beaucoup plus de cas séparés de désintégration nucléaire ([5]).

× 190.

J'ai effectué des expériences ([5]) au niveau de la mer, ainsi qu'à des altitudes jusqu'à 9000 m. Ces expériences ont montré qu'un plus grand nombre de fourches peut être observé à des altitudes et qu'un plus grand nombre de particules y correspond à chaque fourche. A l'examen ultérieur des plaques exposées à l'altitude, une d'elle offrait un cas de désintégration en forme de gerbe (heavy particle burst) d'environ 100 particules lourdes. La figure montre une microphotographie stéréoscopique normale de cette gerbe, faite avec un grossissement de 190. Un certain nombre de plans se trouvant

hors du foyer, la photographie ne peut révéler toutes les traces que l'on peut observer à l'examen stéréoscopique à l'aide d'un microscope.

Comme on le voit sur la photographie, toutes les particules partent d'un seul centre. Le centre se représente comme une tache sombre, où l'on ne peut plus discerner de traces séparées. Il est possible que cet obscurcissement soit causé non seulement par les particules lourdes, mais aussi par le faisceau d'électrons dont cette gerbe fut accompagnée (l'émulsion employée ne reproduisant pas les traces des électrons séparés, on ne les aperçoit pas sur la plaque). Le centre de la gerbe est situé à l'intérieur de la couche d'émulsion (d'une épaisseur de 50 μ). Pendant l'exposition la couche de la plaque se trouvait du côté inférieur (les couches de chaque paire de plaques étaient tournées l'une contre l'autre).

Dans cette gerbe il y a 12 traces au parcours d'environ 18 cm (en comptant par rapport à l'air), disposées dans un cône dont l'angle est d'à peu près 30° au sommet. L'axe de ce cône forme avec la verticale un angle d'environ 70° et est dirigé en bas. Si l'on considère ces particules comme des protons, leur énergie peut être appréciée comme la grandeur du parcours à la valeur de 40 MeV. Les particules plus courtes au parcours d'environ 12 cm forment en divergeant un plus grand angle. Elles sont situées à l'intérieur d'un cône à l'angle de 70°. Le nombre total des particules dans ce cône s'approche de 30, la plupart d'elles étant aussi des protons, comme on peut juger d'après le nombre de grains développés au bout du parcours, bien que les traces isolées ressemblent aux traces des particules α. L'énergie totale de ces particules est d'environ 50 MeV. Il est à noter que la section transversale des cônes en question ne représente pas un cercle, mais s'approche plutôt à des ellipses. Ainsi par exemple la relation des demi-axes réciproquement perpendiculaires pour la première section est 4 : 1 et pour la seconde à peu près 9 : 1.

Les particules au petit parcours dont le nombre est 50—60 divergent encore plus. En calculant leur énergie d'après la courbe pour les protons, le parcours moyen étant de 5 cm, nous obtiendrons une énergie totale de 80—90 MeV.

Tous ces calculs ont été accomplis d'après les courbes de l'énergie des protons en fonction de leur parcours; il en résulte que la limite inférieure de l'énergie des particules de cette gerbe est de 200 MeV. La grande quantité d'énergie, dégagée à la formation de cette gerbe, fut accompagnée de l'apparition de fourches isolées, situées à une petite distance du centre de la gerbe. Par exemple, à l'intérieur d'un cercle dont le centre se trouvait dans les limites de la gerbe et dont le rayon était de 0.4 mm (rayon du champ visuel), on a trouvé 3 fourches de 5 particules, 2 fourches de 4 particules, 1 fourche de 3 particules, 1 gerbe de 4 particules et 2 gerbes de 3 particules, en somme 9 désintégrations nucléaires à l'énergie d'environ 50 MeV sur une superficie de 0.5 mm^2. Cela dépasse 70 fois la densité ordinaire de distribution des fourches sur les plaques que j'ai étudiées. En outre, un nombre considérable de fourches se trouve hors des limites du champ visuel du microscope.

Pour caractériser les fourches mentionnées je me permets de citer les résultats de leur mesure. La première fourche (l'extrême gauche sur la photographie) a des traces appartenant aux protons dont les parcours sont de: 3.7, 8.1, 5.6, 7.4 et 6.1 cm. Les trois premières sont situées entièrement dans l'émulsion, tandis que les trois dernières aboutissent au verre et, à juger d'après la disposition des grains développés, leur longueur réelle surpasse de beaucoup celle qui est mesurée. Il est à noter que les cas, où rien que de petites parties des parcours trouvent leur place dans l'émulsion, ne sont pas rares. Ainsi, par exemple, sur la même plaque (mais à un point éloigné

de la grande gerbe) se trouve une fourche aux longueurs des parcours dans l'émulsion égales à : 2, 4.9, 10.3 et 86 cm. Là aussi la troisième trace aboutit au verre, sa longueur véritable étant sans doute beacoup plus grande que la valeur indiquée (10.3 cm). Quant à la quatrième trace, elle saillit dans l'air et sa vraie longueur dépasse aussi les résultats de la mesure (peut être 2 ou 3 fois). La deuxième fourche (on la voit sur la photographie tout en bas) a l'air d'une gerbe dont le centre est situé à l'intérieur de l'émulsion et dont les composantes appartiennent aux protons. Les parcours des particules dans cette gerbe se terminent tous dans les limites de l'émulsion et leur longueurs calculées par rapport à l'air sont de: 12.2, 9.1, 1.3 et 2.9 cm. L'énergie totale des particules dans cette gerbe est de 7 MeV.

Institut de Radium.
Académie des Sciences de l'URSS.

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PHYSICS

ON THE PHENOMENON OF THE OVERHEATING OF A SOLID BODY

By S. E. HAYKIN and N. P. BÉNET

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In accordance with existing views on how the process of the fusion of a solid body arises, its melting should set in immediately after the temperature of the body has reached the melting point. All facts hitherto known were in perfect agreement with this view. In particular, up to the present time, it was never found possible to observe in the fusion process of a solid body any phenomenon corresponding to surfusion or overcooling of a liquid, in other words, anything like the overheating of a solid body. However, experiments on the fusion of monocrystals of tin conducted by us under specific conditions have led to results which seem to call for a revision of existing conceptions on the matter.

The specific conditions here referred to consisted in the fact that the temperature inside the body exceeded that at its surface. Tin rods, 8—10 mm in diameter and 10—12 cm in length, underwent heating by having direct current of 300—400 amperes passed through them. Since Joule heat is liable to be emitted over the whole section of the rod practically uniformly, while part of the heat is given up through the side surface, the temperature inside the rod had always to exceed that at its surface. Under these conditions the picture of the fusion of polycrystalline and monocrystalline rods appeared to be altogether different. In the case of polycrystalline rods, the liquid tin appeared on the surface of the solid rod by force of bursting through the solid walls of the rod*, whereas in the case of monocrystals the liquid phase appeared on the surface of the solid rod without signs of rupturing the crystal walls. In the case of monocrystals, owing to the vertical position of the rods, the liquid tin appearing on the surface of the solid crystal ran down along the solid walls, forming peculiar incrustations, widely different in their appearance from those ejections of liquid tin from within, which were observable with polycrystalline rods. Thus, regardless of the fact that the distribution of temperatures was in both cases one and the same and that it was necessarily higher inside the rod than outside it, polycrystalline rods offered a picture of fusion proceeding from within (which, indeed, was the very thing to be expected from the usual point of view), while monocrystals gave a picture which, as will be seen from the subsequent, may only be accounted for by admitting that the process of fusion begins from outside.

* This bursting through is caused by the hydrostatic pressure of liquid tin which expands upon fusion.

Yet, in the absence of special cooling of the surface of the rod, heat was lost not so much through the side surface of the rod, but through its ends and into the massive electrodes, between which the rod was clamped in. For this reason the difference in temperatures between the axis and the surface of the rod was found to be under these conditions inconsiderable, namely of the order of 0.2—0.4 degrees. In order to obtain a higher difference of temperatures between the axis and the surface of the rod, artificial cooling of the rods was applied, being effected through intense fanning of the rod surfaces by a current of air directed along the length of the rod. The electrodes which clamped in the rod were carefully protected from fanning and the current of air was made to cool the lateral surface of the rod only. Under these conditions in order to bring the rod to fusion point, currents of 600—700 amperes instead of 300—400 amperes were required. The difference in temperatures between the axis and the surface of the rod during the process of fanning finds its most reliable estimate in a comparison of the power, which has to be applied to the rod in the two cases under consideration, i. e. with fanning and without it, for the purpose of slowly bringing the rod to the temperature of fusion. This condition of slowness in bringing the rod to fusion permits in calculation to regard the whole process as a stationary one, i. e. to assume that the whole power supplied to the rod is expended on heat transfer. The excess of power in the case of fanning over the power expended in the case, when no fanning is resorted to, determines therefore the amount of heat, which in course of fanning is necessarily carried away through the side surface of the rod. Elementary considerations give the following formula for the difference in temperatures between the axis and the surface of the cylinder:

$$\Delta T = \frac{QR^2}{4\lambda},$$

where λ is the heat conductivity, R—the radius of the cylinder and Q—the amount of heat emitted per unit volume, i. e. in our case only that part of the total amount of the heat which is emitted within a unit of volume carried away through the side surface of the cylinder. The difference of temperatures calculated in this way constituted usually in our experiments 1.2—1.5 degrees, and in some experiments reached as high as 2 degrees*. Therefore, on the one hand, in order to be entitled to determine the temperature difference between the axis of the rod and its surface, and on the other hand, to have time to discontinue the further development of the process after having caught the first signs of incipient fusion**, we increased the amperage of the current in the rod as slowly as possible, in such a way as to make the temperature of the rod, when near the melting point, to rise by one degree not faster than within 10—15 seconds. Since in our experiments with fanning about 20—30 small calories per second were carried away through the lateral surface of the rod and since the heat capacity of the whole rod constitutes 2—3 small calories per degree, it follows that the amount of heat remain-

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* In reality, the difference in temperatures should be still greater, since, first, in the middle of the length of the rod the temperature exceeds that at the ends (therefore fusion begins always in the middle of the length of the rod, on account of which we are mainly concerned with the middle); consequently, the resistance of the rod is also higher and, along with this, the amount of emitted heat is also larger; and secondly, it stands to reason that even without fanning a portion of the heat nevertheless passes through the lateral walls of the rod.

** If the process is not discontinued at the very beginning, it will run its further course most violently (due to enhancement of the specific resistance of tin in fusion and to a reduction in the cross-section of the rod) and will terminate in a complete breakdown of the middle portion of the rod.

ing in the rod constituted at any rate no more than 1% of the amount of heat carried away through the walls. This fact undoubtedly entitles us—for purposes of calculations of temperature distribution—to consider our case as stationary.

With the slow heating of monocrystalline rods, intensely cooled from the surface, we also observed two different pictures of fusion. In certain monocrystals rupture of the solid walls of the crystal was to be observed, which testified to the fact that within the crystal the process of fusion had already begun. If the process stopped at the right moment, there would be observed monocrystals with walls ruptured from within, but without any traces of a liquid phase on the surface. Upon filing the rod crosswise at the spot of the burst, a small cavity with fused up edges could always be disclosed inside. Grinding and etching of the section reveals an obviously polycrystalline structure. In short, we have here a perfectly obvious picture of the fusion of a crystal from inside.

In other cases, usually in the most carefully grown crystals*, a different picture could be observed—the liquid phase appeared directly on the solid surface of the crystal without any signs of the rupturing of this surface from inside. In some cases we failed to detect any cavities within the chystal. In other cases we revealed a narrow channel, penetrating more or less deep into the crystal. However, in such cases etching gives always a pure monocrystalline structure, intact but by the channel. The most plausible interpretation of this picture is the following. Melting begins outside and, owing to the temperature inside being higher, penetrates within, forming a channel.

What is then the interpretation we have to give to the picture observed here of the appearance of liquid phase on the surface of a solid monocrystal? In the first place, we might suppose that we had observed something similar to that observed by Volmer and Schmidt ([1]) in connexion with the fusion of gallium crystals. It will be remembered that these authors noticed that the fusion of the surface of gallium crystal begins sometimes not in the point where the temperature is at the highest, but in adjacently located «weak spots» containing impurities and inclusions. It might be supposed that it is just with the careful growing of a monocrystal that some admixture would be pressed out on to its surface, which would either of themselves be apt to lower the fusion point or else give in the process of fanning certain compounds which might lower the fusing point. In order to check this surmise, special control experiments were set up with carefully grown monocrystalline rods, through the length of which a thin aperture was drilled out. It was found that fusion at the internal surface (i. e. in the aperture) began earlier than at the external surface of the rod, this being equally true for the case with fanning and the case without it. This shows that the phenomenon just referred to cannot be explained by the heterogeneity of the material, or by the assumption that the material has almost the same fusion temperature both inside the rod and on its surface.

Further on, we might have made the surmise that the phenomenon observed by us resulted from the rise of the melting point of the internal layers of the rod, owing to the pressure exerted upon them by the outer layers of the crystal. However, this surmise too must be discarded, since any appreciable rise in the melting point of tin necessitates the application of very considerable pressures (about 300 atmospheres for raising the fusion temperature by 1 degree), while the mechanical strength of tin monocrystals—and so much

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* Careful growing consisted in repeated preliminary purifying of the melt from impurities and entrapped gases and in the very slow growing of crystals from the melt.

the more at temperatures close to the fusion temperature of that metal—is very small. The strength of tin monocrystals constitutes already at 200° but 7—10 kg/cm², and at temperatures actually fringing upon fusion temperatures (as this is the case in our experiments) the strength is undoubtedly still by far smaller; yet, we fail to possess any quantitative data concerning this fact. But even adopting the evidently exaggerated figures of 10 kg/cm², we find that a tube of a material of such strength and with walls, whose thickness would be equal, for instance, to the inner radius of the tube, will be able, as shown by elementary computations, to withstand an internal pressure of no more than 15 atmospheres, which corresponds to a rise of the melting point of tin by but a hundredth part of a degree. Therefore, as soon as within the rod a sufficiently large region would be formed, in which the temperature would exceed the melting point but slightly, fusion should set in in this very region attended by plastic deformation or rupture of the external portions of the rod. Thus, we may maintain that the stresses which may exist in the material of the rod are unable to produce even the slightest noticeable change in the melting point of the inner layers of the rod. Therefore, should conditions be such that the fusion of a body would begin immediately as soon as the temperature would reach the melting point, the fusion of the rod ought to start from within, since with a slow rise of the temperature of the rod the temperature of the axis of the rod always exceeds that at the surface. All at the same time, the appearance of a liquid phase on the surface of the solid crystal permits us to assert that fusion begins from outside. Indeed, since the temperature inside the rod is always higher than at its surface, the fusion of the rod inside ought to have begun before the temperature at the surface had reached the melting point. Let us suppose that fusion inside has begun. Absorption of heat will now take place, on account of which the distribution of temperature along the radius of the rod may, generally speaking, undergo some change. But in a homogeneous layer, at whose boundaries any desired conditions are postulated (but, of course, independent of time), there may exist but a single extreme of temperature. Therefore, in the non-fusing layer of our rod, limited on the one side by the outer surface of that rod and on the other side by the fusing inner layer, there may also exist only one extreme of temperature and this can be only the maximum, since heat at any rate keeps streaming outwards from the outer layers. Consequently, also after the beginning of fusion, the distribution of temperature can be either such that temperature monotonously rises from the surface inwards, or else such that it rises up to a certain maximum whereupon it falls, but not below the fusing point (since the temperature of a melting layer cannot in any case be below the melting point). Hence it follows that also after the beginning of fusion inside, further increase in temperature may proceed only in such a way that the temperature of all the inner layers will pass through the melting point earlier than the temperature of the outer surface of the rod. This means that, if the fusion has begun inside, it must necessarily spread from inside out, and it can scarcely be admitted that fusion has begun both from within and from outside, while the intermediate layer remained unmolten. Thus, the appearance of a liquid phase on the surface of a solid crystal can be accounted for by the fact that the crystal starts fusing only from the surface. Consequently, though the temperature inside the crystal exceeds by 1.5—2 degrees that at the surface, i.e. it stands by 1.5—2 degrees above the melting point, the crystal inside does nevertheless not fuse. From this the deduction should be made that for a solid body to fuse it is insufficient that the temperature should reach the point, which is commonly known as the melt-

ing point. In order that fusion might begin, there must be available some further specific conditions. These conditions are, as it appears, always observed at the surface of a solid body and inside polycrystals, but are not always observed in monocrystals. A good monocrystal, in which these specific conditions are absent, may not fuse, even though its temperature should exceed the melting point, i. e. the crystal may exist in an overheated condition.

Adopting the terminology used for the corresponding phenomenon of the overcooling of liquids, it may be said that certain «centres of fusion» are likely to exist, which are always present at the surface of a crystal or polycrystals, yet may be absent inside good monocrystals.

On the ground of our experimental evidence, the conclusion can be drawn that the «better» is the monocrystal, the higher is the overheating which it is able to stand, since, in the absence of fanning, when the overheating constituted 0.2—0.4 of a degree, all monocrystals had the same behaviour—their fusion proceeded from outside; while with fanning, when the overheating constituted 1.5—2 degrees, only some monocrystals, by their outward appearance the better ones, were apt to fuse from outside, while many monocrystals gave a picture of bursting from within.

Further experiments, which we are about to start now, are designed to confirm the validity of our conclusions by more direct and reliable methods.

Institute of Physics.
Moscow State University.

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PHYSICS

INFRA-RED ABSORPTION SPECTRUM OF LIQUID HYDRAZINE

By S. S. KRIVICH

(Communicated by S. I. Wawilow, Member of the Academy, 23. I. 1939)

The hydrazine molecule (N_2H_4) comprises two monovalent amine radicals linked by a single bond. This molecule is of interest for the study of the nature of N—N linkage, as wella as for solving the problem of free rotation of these radicals around the bond.

The measurement of the electric moment of the hydrazine molecule [1] gives a rather high value $1.83 \cdot 10^{-18}$ which suggests either a certain asymmetry of the model of this molecule or a free rotation of the NH_2-groups. The spectroscopic data available do not allow as yet to give a definite answer to this question. The investigations of the ultra-violet spectrum of hydrazine vapour by Imanishi [2] have shown the existence of several intense maxima in the region 2326—2225 Å and continuous absorption from 2200 Å. Hilbendorf [3] investigated the absorption in hydrazine vapour in the Schuman region and found from the determination of intensities a similarity of the hydrazine and the ethylene bands. He determined the heat of dissociation for the N—N linkage as 122.4 cal/mol.

The Raman spectrum of liquid hydrazine in a 10 cm length layer was measured by Imanishi [2] who found the following lines: 900 (weak), 1120, 3212, 3289 and 3339 cm^{-1}. The third, fourth and fifth lines are similar to the triplet detected in the Raman spectrum of liquid ammonia by Daure [4] and correspond to the internal vibrations in the NH_2-groups. Imanishi ascribes the frequency 1120 cm^{-1} to vibration along the N—N bond and considers as possible the rotation of the NH_2-groups around this bond, particularly for excited gaseous state. However, the theoretical calculations of Penney and Sutherland [5] have shown it possible to construct asymmetric models of the hydrazine molecule which would exclude the possibility of free rotation of the NH_2-groups and at the same time would be energetically more stable than the symmetric model. Taking into account that the nitrogen atoms in the hydrazine molecule are in the states $(2s)^2(2p)^3$ and $(2s)\ (2p)^4$, the authors believe the interacting electron clouds of the central atoms to impede the free rotations of the radicals.

Kachovec's and Kohlrausch's [6] investigations of the Raman spectra of hydrazine, hydrazine hydrate, chlorhydrate and dichlorhydrate have revealed the presence of almost similar lines in all the substances. According to the measurements of these authors, the frequencies for Raman lines of hydrazine are as follows: 876, 1108, 1620, 3181, 3263 and 3332 cm^{-1} and for weaker lines—174, 583 and 702 cm^{-1}. The line 1620^{-1} appears when

a Raman spectrum is excited by mercury arc radiation passed through a filter.

I examined the absorption spectrum of liquid hydrazine from 1 to 14 μ by means of Hilgers infra-red spectrometer with changeable prisms of quartz, fluorite and rock-salt. The quartz prism was used for the region 1—3.5 μ, the fluorite prism for 2.5—8 μ and the rock-salt prism for 8—14 μ region. A tungsten lamp with a straight filament for 50 V served as the source of radiation for the region 1—2.5 μ, while for the 2.5—14 μ part of spectrum was used a Nernst lamp. The radiation was received by a Hilger thermopile (manganin-constantan) with Hartmann-Braun galvanometer. Hydrazine was obtained from $N_2H_4.H_2O$ by a series of distillations with barium and caustic alkali. Hydrazine hydrate was produced by distilling $N_2H_4.H_2SO_4$ with caustic alkali. In this manner was prepared a small quantity of comparatively pure hydrazine with a melting point at about—0.5° C, while according to literary data it is 1° C. We had to abstain from further distillations because of the paucity of the material obtained. Approximate evaluation gave an admixture of hydrazine hydrate not exceeding some per cent.

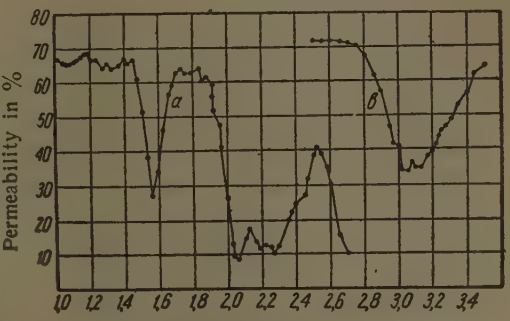

Fig. 1. Permeability curve of liquid hydrazine: *a*) d=0.5 mm; *b*) d=0.005 mm.

The absorption of hydrazine is very intensive in the infra-red, thus it proved necessary to use very thin layers of the order 0.02—0.005 mm for the 2.5—14 μ part of spectrum and 0.5 mm for the 1—2.5 μ region. The layers were placed between two fluorite or rock-salt plates. In Fig. 1 and 2 there are represented permeability curves. From the consideration of these curves the following strong bands may be traced: 11.3, 9.1, 6.2 and about 3.1 μ. The weak bands are at 7.55, 2.0—2.35 and 1.57 μ. By a more detailed investigation of the band 3.1 μ with a quartz prism * there were found two weak maxima of absorption at 3.06 and 3.13 μ. In the region 2.0—2.35 μ it is possible to discern three absorption maxima: 2.07, 2.19 and 2.28 μ. In the table are given the frequencies of these bands and comparative Raman spectrum data as obtained by Kahovec and Kohlrausch, as well as the ammonia spectrum for sake of comparison.

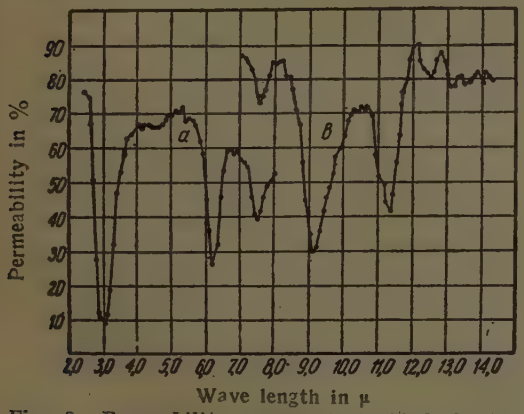

Fig. 2. Permeability curve of liquid hydrazine. *a*) d=0.02 mm; *b*) d=0.005 mm.

* The measurement in the region was somewhat impeded the quartz itself having a strong absorption band about 3.0 μ.

Infra-red spectrum of N_2H_4		Raman spectrum of N_2H_4	Infra-red spectrum of NH_3	
λ, μ	ν, cm^{-1}	ν, cm^{-1}	type of oscillations	ν, cm^{-1}
—	—	174		
—	—	583		
—	—	702		
11.3	885	876	$\delta(\pi)$	950
9.1	1097	1108		
7.55	1324	—		
6.2	1613	1620	$\delta(\sigma)$	1630
3.13 / 3.06 } 3.1	3195 / 3268	3181 / 3263		
—	—	3332	$\nu(\pi)$	3335
2.28 / 2.19 / 2.07 } 2.0—2.35	4387 / 4556 / 4831	— / — / —		
1.57	6370	—		

From the compared data of the table it may be concluded, in the first place, that some of the frequencies of the infra-red spectrum and of the Raman spectrum closely coincide and, in the second place, that there exists some approximation to the frequencies of NH_3 spectrum. Frequencies 1613 and 885 cm^{-1} may be compared with 1630 and 950 cm^{-1} of the ammonia spectrum. Frequencies 3195 and 3268 cm^{-1} which correspond to Raman lines 3181 and 3263 cm^{-1} can be ascribed to two different internal oscillations in the NH_2-groups. Frequency 1097 cm^{-1} may possibly correspond to vibrations of the NH_2-groups along the N—N axis. The higher intensity of this infra-red band and its weakness in the Raman effect confirms the computations of Penney and Sutherland and evidences the asymmetry of the hydrazine molecule. Frequency 1324 cm^{-1}, absent in the Raman spectrum, either corresponds to one of the active vibrations, or else is a combination frequency. Band 1.57μ must be the first overtone of the band 3.13 μ. The other frequencies are probably pure combination frequencies. This is only an approximative interpretation of the obtained results which should be made more precise with the accumulation of more abundant experimental data. The schemed measurements of the infra-red absorption spectrum of hydrazine vapour will possibly introduce some changes in this interpretation.

In conclusion I wish to express my gratitude to A. I. Kulikov for his help in obtaining and purification of hydrazine.

Physical Laboratory
of the 2-nd Leningrad Medical Institute.
Leningrad Technological Institute.
Laboratory of Optical Methods of Researches.

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PHYSICS

ISOTOPIC DISPLACEMENT OF THE LINES OF SAMARIUM

By M. VANJUKOV and S. FRISCH

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Schüler and Schmidt (1) were the first to measure the structure of a line of samarium, viz., λ 5321 Å. Confronting the results obtained with the isotopic constitution of Sm determined by Aston (2), they inferred that the complex structure is due to the isotopic displacement of the lines and that the magnetic splitting of the lines of the odd isotopes Sm^{147} and Sm^{149} is insignificant, as compared to the isotopic displacement. According to them, the magnetic splitting produces only a certain broadening of these lines, which prevents the resolution of the blend formed by the lines of the isotopes Sm^{147}, Sm^{148} and Sm^{149}. Furthermore, Schüler and Schmidt have detected that the intervals between the lines of the even isotopes are not equal, while for the other elements, which display isotopic displacement, the lines are always situated at regular intervals. The interval between the lines of Sm^{150} and Sm^{152} is about twice as large as that between the lines of the other corresponding pairs of even isotopes. According to Schüler and Schmidt, this anomaly is connected with the α-radioactive properties of samarium (3).

An uncompletely resolved structure of Sm lines was observed by King (4), who worked with a 15-foot concave grating. He does not consider it as ascertained that the structure of lines is due only to the isotopic displacement.

From our viewpoint, any conclusions as to the nature of the structure of lines and, in particular, about a new anomalous effect in the isotopic displacement, founded on the analysis of a single not completely resolved line, are not convincing.

It seemed therefore desirable to continue the investigation of the hyperfine structure of Sm lines. As a source of light a tube with a hollow cathode cooled by means of liquid air was used. The laboratory disposed only of the nitrate of samarium which, when simply inserted in the hollow cathode, did not produce any radiation. Therefore a method was developed of employing rare earth nitrates for different sources of light for spectra. The nitrates of rare earths together with the nitrates of argentum were reduced on the carbon. A hollow cathode was prepared in the following way. First of all the samarium nitrate was gradually added to the nitrate of argentum which had been previously smelted. The resulting compound was reduced in the hollow cathode, turned out of brass, whose walls were either smoked preliminarily or coated with a paste made of soot and sugar syrup. A thin foil of silver and samarium was thus obtained. This foil was smoked anew, and the reduction was reproduced. This procedure was repeated for 20—40 times, until a foil about

1—2 mm thick was obtained. The hollow cathode prepared in such a manner could work up to 100 hours and produced a sufficiently bright radiation.

The spectrum was photographed by means of etalons of Fabry and Perrot 6.563, 15.243 and 19.809 mm thick combined with a glass biprismatic spectrograph of the State Optical Institute. The exposure lasted for 1.5 hours, while the tube took the current 60 mA. The best photographs were obtained when the 15.243 mm etalon had been used. These plates were used for our measurements.

The structure was observed for several lines, but the best resolved were λ 5321 Å (previously measured by Schüler and Schmidt) and λ 5252 Å. Both lines reveal a similar structure; each consists of 4 components, denoted in succession by *a*, *b*, *c* and *d*. The distances between these components in Å are given in Table 1.

Table 1

	a—*b*	*b*—*c*	*c*—*d*	*a*—*c*	*a*—*d*
5321Å	0.019	0.030	0.012	0.050	0.062
5252Å	0.014	0.030	0.011	0.043	0.054

As the width of the structure of a line is about the same magnitude as the distance between the orders of the etalon, photographs with one etalon only can give no definite answer as to the order of the components in the range of frequencies.

The additional photographs with the etalon 19.803 mm thick have shown the frequencies to continuously increase from the component *a* up to the component *d*. Table 2 gives the results of the measurements of the structure of the line λ 5321 Å made by Schüler and Schmidt. In the first row are given the numbers of the isotopes, whose line intervals correspond to the measured differences of wave lengths. The second row contains these differences of wave lengths for the components.

Table 2

	148—150	150—152	152—154	148—152	148—154
5321Å	0.019	0.029	0.014	0.048	0.062

If we consider the component *a* as corresponding to the isotope Sm^{148}, the component *b*—to the isotope Sm^{150}, the component *c*—to the isotope Sm^{152} and, finally, *d*—to the isotope Sm^{154}, the agreement between our measurements and those of Schüler and Schmidt is rather good. When the 15.243 mm thick etalon is used, the line of Sm^{144} coincides with the line of Sm^{154} of the adjoining order and cannot be measured. The intensity of the components, estimated purely qualitatively, is in agreement with the percentage abundance of isotopes, according to Aston.

The classification of Sm spectrum was given by Albertson ([5]); according to him, the lines λ 5321 Å and λ 5252 Å are due to Sm I and have a common lower level $4f^6\,6s^2\,{}^7F_4$ and different upper levels.

The nature of the upper levels denoted by Albertson as $A_4(_3)$ and A_5 is not exactly known, but it is most likely that they belong to the electron configuration $4f^6\,6s6p$. The fact that both lines possess the same structure

(as seen from Table 1), a common low level, but different upper levels, proves that this structure is due to the splitting of the lower level. The lower level belongs to the shell $4f^6\,6s^2$ with two electrons and its magnetic splitting cannot be considerable, while it can easily display an isotopic displacement. Thus, the comparison of the splitting of two Sm lines confirms the hypothesis of Schüler and Schmidt about the isotopic nature of the structure of Sm lines.

Taking into consideration that the frequency of the lines of Sm^{148} is lower than that for Sm^{152}, it is possible to construct a scheme of transitions for both lines investigated.

Thus, the joint analysis of the two lines and their terms makes it possible to ascertain the isotopic nature of the structure of Sm lines, the negative sign of the isotopic displacement, and confirms the presence of an anomaly in these displacements.

Laboratory of Atomic and Molecular Spectroscopy.
Optical Institute.
Committee for the Investigation of Rare Earths.
Academy of Sciences of the USSR.

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PHYSICS

APPLICATION OF A PROPORTIONAL AMPLIFIER TO X-RAY STRUCTURE ANALYSIS

By B. ISAJEV

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In our preceding works we described a method for measuring the intensity of X-rays with the help of a proportional amplifier ([1], [2], [3]). To exemplify the method we performed measurements of the distribution of energy within the white spectrum of tungsten, of the dependence of the intensity of the $K\alpha$-line of molybdenum upon the tension on the X-ray tube and so on.

The present paper is devoted to a description of the application of a proportional amplifier in structure analysis.

As is well known, the magnitude of energy dispersed by a crystalline powder in Debye's method constitutes but an insignificantly small part of the energy falling upon the specimen (of the order of 10^{-6}—10^{-3}).

In the case of muscular tissues or such like substances this magnitude is still smaller.

Investigation of Muscular Tissue. Investigations of the texture of muscular tissue with the help of a photometer have been accomplished by a number of investigators. Owing to the very low dispersivity of tissues, the investigations were always conducted with an X-ray tube and cells specially designed for the purpose (Seemann). The application of a powerful beam of X-rays, as well as of a sensitive photographic material, afforded the authors the possibility to shorten the time of exposure down to 6 min.

Outstanding interest belongs also to the study of the changes in the texture of a muscle in contraction and under the action of foreign agents; this study is, however, complicated by the fact that the duration of these processes is shorter than the time required for exposure.

Besides this, the use of X-rays of high intensity may of itself change the structure of biological specimens. Accordingly, the substitution of an ionization method for a photographic one in this field represents a problem of the utmost importance.

The application of a proportional amplifier affords the possibility of carrying out all measurements in a direct way, according to Bronson's method, with the use of an electrometer, this being possible even in the case of very low power of X-rays.

Our proportional amplifier consisted of an aluminium cylinder (R_1—14 mm and l—185 mm) with an axially drawn on filament (r_1—0.05 mm). The cylinder with the filament was inserted in a sealed off brass container. The front wall with a celluloid window for admission of the rays was provided with a tubus with two slit diaphragms 6 mm in height and with a breadth

varying according to the material used (0.6 mm in investigating muscular tissues and 0.2 mm for a metallic specimen). As a filler, we used a mixture of krypton and air (200 mm of Hg Kr and 100 mm Hg of air). The proportional amplifier as well as the specimen under investigation were mounted on a spectrograph equipped with two circular diaphragms having the following radii: 0.25 mm (for the metal specimen) and 0.8 mm (for the muscular tissue). The distance between the diaphragms equalled 100 mm. The distance from the focus of the X-ray tube (with iron anode) to the specimen (the axis of the spectrograph) amounted to 180 mm, while the distance from the specimen to the front wall of the proportional amplifier was 60 mm. The high sensitivity of the proportional amplifier (coefficient of amplification of the order of 10^4) permitted to perform measurements of ionization currents on a Lutz' electrometer of low sensitivity (30—50 divisions per volt).

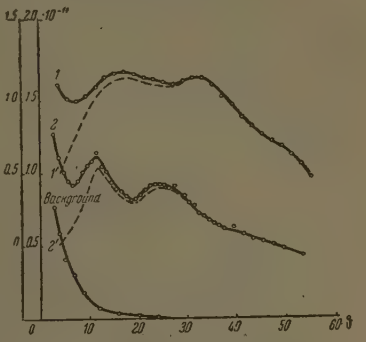

Fig. 1.

Herzog and Janke, as well as Boehm [4] obtained powdergrams of muscles in the form of two diffuse rings, corresponding to periods of identity of 10 and 4.7 Å. On the inner ring a certain equatorial condensation was sometimes observable, characterizing the predominant orientation in the tissue.

Thus, the powdergram of a muscle resembled the powdergram of α-keratine.

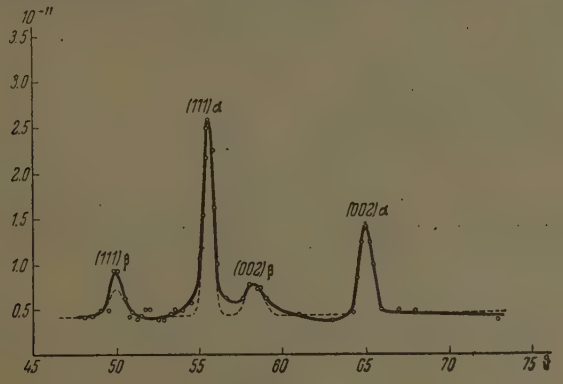

Fig. 2.

As investigation material, we took m. sartorius of a frog studied formerly by Boehm. Fig. 1 represents the distribution of intensity obtained within the equatorial plane of the powdergram.

Curve *2* refers to the muscle dried out when extended. On the curve two maxima corresponding to periods of identity of 10 and 4.5 Å are distinctly to be seen. The maxima are thrown into yet bolder relief, if the magnitude of the background in the absence of the muscle (dotted curve) be subtracted. This background is caused by dispersion through the edges of the diaphragm, etc., and is to be seen at the bottom of Fig. 1. Curve *1* of Fig. 1 characterizes the muscle in its fresh state (the muscle is similarly stretched

out upon a special bench). The sharply marked maxima vanish and the space between them is filled with a disperse background.

It will be seen from the curves that with the drying up, a shift in the position of the maxima takes place, running in the direction of smaller angles. Where the reason for this lies, is so far difficult to say. An investigation into the reasons for this phenomenon is at present under way. It is also worth noting that notwithstanding the low intensity of the beam falling upon the material under investigation (in our work the intensity of radiation falling upon the muscular fibre was 100 times lower than in Boehm's work), the ionization currents arising in the proportional amplifier attained the magnitude of 10^{-11} A (in an ionization chamber these currents would have been of the order of 10^{-15}).

Metal Specimen. As our second investigation material copper was chosen, taken in the form of a thin plate (X-ray trans-illumination). Small-grain structure was brought about preliminarily by tempering at 200 C. In Fig. 2 a powdergram of copper is to be seen. A control photograph on a sensitive film under the same illumination conditions necessitated an exposure of 4.5—5 hours (5 mA, 30 kV, the film being of a sensitivity of 700 X and D; made at the Semashko Works). The dotted curve in Fig. 2 represents the results of microphotometering. The ratio of the intensities of lines (111) and (002) according to the protomicrograph is equal to 2.12, while the same ratio as obtained by means of the proportional amplifier equals 2.15.

By using the same method we, while working jointly with our co-worker Kojin, accomplished measurements of the intensities of 40 reflections from a monocrystal of amino-acetic silver. Notwithstanding the inconsiderable size of the crystal (0.01 mm^3 in volume), the ionization currents reached the magnitude of 10^{-10} A. At the time of writing, the work on the calculation of the structure being performed by Kojin and Kitaigorodsky is nearing its termination.

Section of Photobiology
All-Union Institute of Experimental Medicine.

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CHEMISTRY

EFFECT OF SOLVENT ON KINETICS

By A. S. SELIVANOVA and J. K. SYRKIN

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1. The problem of the effect of the solvent on kinetics has been the subject of wide discussion in the chemical literature. The most numerous are the attempts to connect the reaction velocity with some macroscopic property of the solvent, e. g. with its dielectric constant. In a number of recent papers the velocity was correlated with the dipole moment of the solvent. However, one cannot say that all these attempts gave results of any general significance. Evidently, in each particular case it is necessary to take into account the specific mechanism for the given reaction and the character of any possible interaction with the solvent. Solubility in itself is selective and is conditioned in each sepatare case not merely by the total magnitude of the van der Waals' forces, but by the values of its individual components (orientation, induction, and dispersion forces). In this connexion some rôle may be played by steric conditions, and in a number of cases also by specific interaction which is connected with the structure, as, for example, the hydrogen bond and the like. The lack of knowledge of the solubility of an active complex in different solvents makes the interpretation of the kinetic results more difficult.

Certain interest is provided by those investigations in which some isolate reaction is studied in different solvents, and the dependence of the energy of activation and of the pre-exponential factor upon the solvent in the equation $K = Ae^{-E/RT}$ are sought. However, in this connexion two facts must be taken into account. The Arrhenius equation is often correct only in the first approximation. Thus, in the case of the well-known and much studied reaction of the saponification of esters, the energy of activation calculated according to the Arrhenius equation noticeably decreases with a rise in the temperature within a comparatively narrow interval ([1]). At the same time this reaction was often used as an example of kinetics, which fits exceptionally well into the Arrhenius equation. This shows that in a number of cases, if the kinetics is studied thoroughly, the constancy of the energy of activation is very approximate. The Arrhenius equation often holds not because the facts are such, but because the authors assume that it does so. Sufficient attention is not being paid to this in chemical kinetics. In any case, if a reaction is studied in various solvents, and the energy of activation is found to change insignificantly, this should not give grounds for serious conclusions. The second complicating circumstance is the fact that the reaction velocity constant very often depends upon the concentration of the reactants. Such a dependence was observed, for example, in the case of the much studied

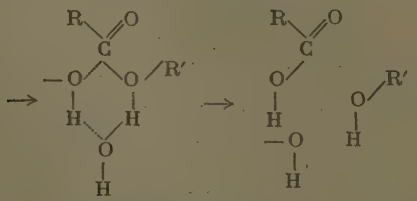
kinetics of the formation of quaternary ammonium salts (2). These circumstances decrease the importance of the conclusions made in a number of investigations which have appeared right up to the present time.

Investigations of the kinetics, when the solvent is a binary mixture having a variable composition, are of particular interest. In this case one may follow the change in the velocity by its dependence upon the continuous change in the composition. Existing data indicate that in the majority of cases the velocity constant is not a linear function of the composition. If in one solvent the energy of activation is equal to E_1, and in another to E_2, and $E_1 > E_2$, then usually in a binary mixture the reaction proceeds with an energy of activation nearer to E_2 than to E_1. Thus, in a mixture predominates the action of the more active solvent, i. e., of the one in which the reaction proceeds with a smaller energy of activation. The reaction tends to proceed at a greater rate, and the greater influence is shown by the component of the binary mixture, in which the velocity is greater (3). The haphazard choice of binary mixtures, which is very often the case, makes, however, the interpretation of the results and the attempt to generalize them more difficult.

In the present investigation was studied the kinetics of the saponification of ethyl acetate in the presence of sodium hydroxide. Water was employed as the solvent, to which variable quantities of one of the following alcohols were added: CH_3OH; $C_2H_4(OH)_2$—ethylene glycol; $C_3H_5(OH)_3$—glycerol; $C_4H_6(OH)_4$—erythrite; $C_6H_8(OH)_6$—mannitol. The concentration of glycerol varied from 5 to 80%, of ethylene glycol from 20 to 40%, of erythrite from 10 to 20% and of mannitol from 5 to 15%. All the binary mixtures were made up in the same manner. One of the components was water, while the other was a mono- or a polyatomic alcohol, i. e. substances of the same chemical nature, but possessing a variable number of hydroxyl groups. The problem consisted in establishing the influence of the chemical nature of the solvent on the kinetics. It was interesting to ascertain whether a single molecule of erythrite would be equivalent to the action of two molecules of ethylene glycol. The kinetics was studied at three temperatures: 15, 25 and 35°C. The concentrations of ethyl acetate and sodium hydroxide were about 0.023 moles per liter.

The alkaline hydrolysis of an $RCOOR'$ molecule, in the presence of an $O\bar{H}$ ion, may be represented in the following manner:

$$RCOOR' + O\bar{H} + H_2O \rightarrow$$



In this hydrolysis an alcohol is formed by the union of the R'O of an ester molecule with a hydrogen of the second component of the reaction.

The transition state is apparently a complex made up of an ester molecule, water and a hydroxyl ion. Alcohols, both mono- and polyatomic, affect the kinetics negatively, decreasing the probability of the transition state and retarding the reaction. The intermolecular action of alcohols and water is caused to a considerable extent by the hydrogen bonds. This is likewise evident, as a matter of fact, from viscosity measurements.

Association of alcohols is caused by the hydrogen bond. The anomalous course of orientation polarization is caused by the considerable interaction and by the retardation of the free rotation of the molecules in the liquid. In the case of a polycomponent solution, association is realized by the interaction of the alcohol-hydroxyl groups with molecules participating in the reaction. This makes the formation of an active complex more difficult. If these concepts correspond to reality, retardation of the reaction should be a function of the number of hydroxyl groups.

The results of the experiments with admixtures of ethylene glycol, glycerol, and erythrite are given in Table 1. In the first column is given the solvent; in the second, the number of moles of alcohol per liter of solution; in the third, the corresponding concentration of the OH-groups (the product of the molecular concentration by the number of hydroxyl groups). Then the rate constants are given for 15, 25 and 35°C, calculated according to the equation for a second order reaction. The time is expressed in seconds; the concentration, in gm-moles per liter. Finally, in the last columns there are given the ratios of the rate constants: K_{25}/K_{15} and K_{35}/K_{25}.

Table 1

Solvent	Moles per liter	OH-groups per liter	K_{15}	K_{25}	K_{35}	K_{25}/K_{15}	K_{35}/K_{25}
Water	—	—	0.0450	0.089	0.160	1.98	1.80
5% glycerol in H_2O	0.543	1.63	0.0370	0.074	0.134	2.0	1.81
10% » » »	1.087	3.26	0.0319	0.062	0.116	1.94	1.87
10% erythrite » »	0.82	3.28	0.0320	0.064	0.116	2.0	1.81
20% glycerol » »	2.17	6.51	0.025	0.050	0.100	2.0	2.0
20% erythrite	1.63	6.52	0.026	0.051	0.096	1.96	1.88
20% ethylene glycol	3.22	6.44	0.025	0.051	0.102	2.04	2.0
40% glycerol	4.34	13.02	0.0140	0.029	0.059	2.07	2.03
40% ethylene glycol	6.45	12.90	0.0145	0.030	0.0579	2.06	1.93
80% glycerol in H_2O	8.69	26.07	0.0038	0.0077	0.0153	2.02	1.98

Upon examining Table 1 the following regularity becomes evident. The decrease of the rate in a solution containing a polyatomic alcohol and water is determined by the number of hydroxyl groups present. Ten percent solutions of glycerol and erythrite contain a different number of moles per liter (1.087 and 0.82), but the same number of OH-groups (3.26 and 3.28). In both of these solutions the rate constant has the same value (0.319 and 0.320). The same holds for the 20% solutions of glycerol, erythrite and ethylene glycol which contain 6.51, 6.52 and 6.44 OH-groups respectively. The rate constants in these solutions are equal to 0.025, 0.026 and 0.025 respectively. The same law holds for the more concentrated solutions (40%). In other words, the addition of three molecules of erythrite to water lowers the velocity constant by the same amount as the addition of four molecules of glycerol, or of six molecules of ethylene glycol. If a graph is constructed by plotting the rate constants on one axis and the concentration of the OH-groups on the other, all points for the above-mentioned polyatomic alcohols will lie on one curve. All the rate constants of Table 1 may be represented by one equation:

$$K = K_0 G^{-C_{OH}}$$

where K is the rate constant in a solution having a concentration of alcohol hydroxyls equal to C_{OH}, K_0—the rate constant in water, G—a certain con-

stant. The values of G for all the solutions at the three temperatures studied are presented in Table 2.

Table 2

Solvent	G at 15°	G at 25°	G at 35°
5% glycerol	1.127	1.120	1.115
10% »	1.111	1.117	1.104
10% erythrite	1.110	1.106	1.103
20% grycerol	1.094	1.092	1.075
20% erythrite	1.088	1.089	1.081
20% ethylene glycol	1.095	1.090	1.073
40% glycerol	1.094	1.090	1.078
40% ethylene glycol	1.092	1.088	1.082
80% glycerol	1.099	1.098	1.094
Average	1.101	1.099	1.089

In the solutions containing mannitol or methyl alcohol the rates are also reduced as compared to the reaction in pure water, mannitol reducing the rate constant to a greater extent. However, the relations which hold very well for the solutions containing ethylene glycol, glycerol, and erythrite do not hold in this case. Table 3 contains the results of corresponding experiments.

Table 3

Solvent	Conc. (in mol/l)	OH-groups per liter	K_{15}	K_{25}	K_{35}	K_{25}/K_{15}	K_{35}/K_{25}
5% mannitol in H_2O	0.274	1.64	0.0248	0.0494	0.090	1.99	1.82
10% » » »	0.549	3.29	0.0202	0.0415	0.0724	2.05	1.74
15% » » »	0.824	4.94	0.0159	0.0328	0.0605	2.06	1.84
10% CH_3OH » »	3.12	3.12	0.0420	0.0836	0.152	1.99	1.81
20% » » »	6.25	6.25	0.0290	0.058	0.110	2.0	1.89
40% » » »	12.5	12.5	0.00885	0.0185	0.0365	2.09	1.97

It is seen from the data included in Tables 1 and 3 that the Arrhenius equation is only approximately correct. For the reaction in water the energy of activation is approximately equal to 11 200 cal., while for polyatomic alcohols the energy of activation is about 11 800 cal. Thus, the admixture of glycerol, for example, increases the energy of activation by 600 cal. which corresponds to a 3.5-fold decrease in the constant. Actually the velocity in a concentrated solution is only one-twelfth of its value in water. This means that the decrease in the rate is caused partly by the increase in the energy of activation and partly by the decrease in the pre-exponential factor.

2. Besides the reaction rates, we also measured the viscosities of the solutions, in which the reaction proceeded. The results are presented in Table 4.

The results obtained permit us to draw the following interesting conclusion. The viscosities of solutions of ethylene glycol, glycerol, erythrite and mannitol in water are practically the same for all solutions which contain the same concentration of hydroxyl groups. One mannitol molecule increases the viscosity to the same extent as 1.5 molecules of erythrite, 2 molecules

Table 4

Solvent	Conc. of OH-groups	Viscosity		
		at 15°	at 25°	at 35°
Water	—	0.0112	0.00897	0.00724
5% glycerol	1.63	0.0128	0.00947	0.00794
5% mannitol	1.64	0.0126	0.0113	0.00833
10% glycerol	3.26	0.0141	0.0114	0.0094
10% erythrite	3.28	0.0149	0.0120	0.0091
10% methyl alcohol	3.12	0.0147	0.0117	0.0088
10% mannitol	3.29	0.0150	0.0113	0.0083
20% glycerol	6.51	0.0191	0.0153	0.0119
20% erythrite	6.52	0.0191	0.0152	0.0117
20% ethylene glycol	6.44	0.0194	0.0149	0.0117
20% methyl alcohol	6.25	0.0180	0.0140	0.0087
40% glycerol	13.02	0.0317	0.0278	0.0209
40% ethylene glycol	12.90	0.0340	0.0250	0.0187

of glycerol, or 3 molecules of ethylene glycol, which corresponds to the fact that all such molecular concentrations contain the same number of hydroxyl groups (six). This effect of increasing the viscosity is undoubtedly due to the hydrogen bonds. Solutions made up according to the same type have the same viscosities, if they contain equal numbers of hydrogen bonds.

Laboratory of Physical Chemistry.
Institute of the Technology of Fine Chemicals.
Moscow.

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CHEMISTRY

ROENTGENOGRAPHIC INVESTIGATION OF SILICIC ACID GELS

By S. K. DUBROVO

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Numerous studies ([1],[2],[3],[4]) on silicic acid gels proved that the structure of the gels and the physico-chemical properties connected with their structure depend upon various factors: the manner of production, the acidity of the medium, the drying conditions, the thermal treatment, the presence of admixtures etc.

Calculation of the Dispersion Angle

No	Specimen	Diameter of chamber	I ring		II ring		III ring		IV ring		V ring	
			$2r$ in mm	ϑ in degr.	$2r$ in mm	ϑ in degr.	$2r$ in mm	ϑ in degr.	$2r$ in mm	ϑ in degr.	$2r$ in mm	ϑ in degr.
1	Quartz crystall. .	30.55	13.7	—	21.0	—	26.2	—	32.0	—	39.2	—
2	Silicic acid gel A (from sodium silicate), ...	30.0	9.0	8°38′	—	—	—	—	19.5	18°37′	—	—
3	Silicic acid gel B (from silicon tetrachloride) . .	30.0	9.0	8°38′	—	—	—	—	19.3	18°25′	—	—
4	Silicic acid gel A calcined	29.52	10.0	9°55′	—	—	—	—	—	—	—	—
5	Silicic acid gel B calcined	30.55	11.0	10°11′	15.0	14°5′	17.0	15°56′	19.0	17°49′	23.0	21°35′
6	Silicic acid gel A+10% $BaCl_2$.	30.55	10.4	9°45′	15.0	14°5′	—	—	19.2	18°0′	—	—
7	Silicic acid gel A+10% $CuCl_2$.	29.52	9.1	8°49′	—	—	—	—	19.3	18°44′	—	—
8	Silicic acid gel +10% $CuCl_2$ calcined	30.55	9.3	8°50′	—	—	—	—	—	—	22.8	21°23′
9	Type B gel with traces of potassium chloride, calcined	30.55	10.0	9°23′	—	—	—	—	—	—	—	—
10	β-cristobalite * . .	—	—	—	—	—	—	—	—	17°49′	—	21°01′
11	β-tridimite * . . .	—	—	10°10′	—	14°54′	—	—	—	17°48′	—	21°25′

* The data for cristobalite and tridimite are taken from the Report of the

All this shows that there is no uniform opinion concerning the factors which influence the formation of the molecular structure of silicagels.

In order to examine the process of crystallization of silicic acid gels at its very start, as well as the influence of the medium's pH, and of admixtures present on the structure of gels, we prepared two series of the latter. The first series A was produced by acting with hydrochloric acid on a 5% solution of pure, recrystallized sodium silicate. After purifying by dialyzing through parchment to negative Cl' reaction, solutions of different electrolytes were added to separate portions of the slightly coagulated sols, viz: $BaCl_2$, $CuCl_2$, $FeCl_3$ etc. (10% to the dry residue). One portion was left without admixtures. The pH of the pure, coagulated sol, measured by means of glass electrodes, was 5.55.

The second series B was prepared by hydrolyzing silicon tetrachloride after Ebler and Fellner's method ([9]). Before purifying by dialysis the same electrolytes as in series A were added to separate portions of this sol. One portion was left again without admixtures. After the electrolytes were added, these sols were dialyzed to a negative Cl' reaction. The pH of the pure, coagulated sol was 4.50. Afterwards both series of gels were isothermically evaporated to constant weight at 25° in a thermostat over concentrated sulphuric acid. After being thus dried, the gels still contained from 6.5 to 17% water.

Thus, the first stages of the structural formation of type A gels took place in the absence of admixtures. In the case of type B gels the electrolytes were present from the very start of coagulation. The difference, which may pos-

from Exographs of Silicic Acid Gels

VI ring		VII ring		VIII ring		IX ring		X ring		XI ring		XII ring	
2 r in mm	ϑ in degr.	2 r in mm	ϑ in degr.	2 r in mm	ϑ in degr.	2 r in mm	ϑ in degr.	2 r in mm	ϑ in degr.	2 r in mm	ϑ in degr.	2 r in mm	ϑ in degr.
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	29.0	27°40′	—	—	—	—	—	—	36.8	35°0′	—	—
—	—	29.0	27°40′	—	—	—	—	—	—	36.5	34°44′	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
25.0	23°27′	29.0	27°12′	30.5	28°36′	32.7	31°23′	35.0	32°48′	37.0	34°40′	40.2	37°42′
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	28.7	27°51′	—	—	—	—	—	—	37.0	35°55′	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	28°8′	3	31°59′	—	—	—	34°11′	—	37°43′
—	23°33′	—	27°51′	—	28°27′	—	31°59′	—	33°01′	—	34°10′	—	37°42′

State Institute of Optics for 1934.

sibly appear in the structure of silicic acid gels of A and B type, must be due to either their different origin (the possibility of the presence of adsorbed sodium ions in type A, different acidity of the medium at the moment of coagulation, etc.) or to the different method of adding the electrolytes.

A dried pulverized gel sample was mixed in a celluloid tube* 0.7 mm in diameter, and was studied after the X-ray method. X-raying was done after the powder method of Debye-Sherrer. The X-ray source was a Coolidge electron tube with a copper anticathode. The tension used was about 25 kV, the current strength about 10 mA. The Debye chambers with vacuum devices had a radius of about 15 mm, which was calculated on the basis of copper exographs. We obtained the exographs of the following preparations: 1) crystalline quartz; 2) silicic acid gel, type A, containing 16.8% moisture; 3) silicic acid gel, type B, containing 6.58% moisture; 4) the same type A silicic acid gel, calcined over a gas burner in a platinum crucible to constant weight for two hours at a temperature of 900—940°; 5) the type B of silicic acid gel, heated under the same conditions as sample № 4; 6) type A gel containing 10% $BaCl_2$ and 10% H_2O; 7) type A gel containing 10% $CuCl_2$, heated in a crucible furnace to constant weight at a temperature of 800°; 9) type B gel with traces of potassium chloride, heated in a crucible furnace to constant weight at 800°.

For gels the exposure time was 36 hours, for preparations of the quartz-cristobalite type 14—15 hours. The dispersion angles ϑ were calculated by measuring the distance $2r$ between two sections of the Debye ring which are symmetric in relation to the direction of the primary rays. The following formula is used in these calculations: $\text{arc}\, 2\vartheta = \frac{2r}{2A}$, where A is the chamber's radius. The data are given in the table.

On the exographs of pure type A and B silicic acid gels (samples 2 and 3) there were 4 slightly worn diffraction rings. This circumstance shows that the gels contain crystals of dimensions $<10^{-5}$ cm.

This also confirms the supposition of the investigators mentioned above to the effect that crystallization begins in the gel in the first stages of its formation. The exographs of pure type A and B gels, differing in their pH values, do not show any material difference. The fact that the dispersion angles are equal (table) confirms the identical positions of all four Debye rings. The exographs of calcined pure type A and B silicic acid gels (samples 4 and 5) were different. While only one ring was distinctly visible on the A gel exograph, the B gel exograph had about twenty narrow distinct Debye rings. This circumstance shows that we have here a typically crystalline substance, whose crystals have dimensions from 10^{-3} to 10^{-5} cm. Evidently, silicic acid gels may be transformed into a typically crystalline substance at as low a temperature as 900—950°. The type B gel with traces of KCl (sample 9) after being calcined at 800° gave an exograph with one ring. Thus, insufficient calcining results in the disappearance of three rings. It is possible that this phenomenon is connected with the liberation of chemically bound water at these temperatures (decomposition of hydrates). At the same time 800° is not a high enough temperature for crystallization to continue.

As has been mentioned above, a number of investigators believe that silicagels contain crystals of β-cristobalite, and that tridimite is produced only under special conditions. If the dispersion angles on the exographs obtained by us are compared with those calculated for cristobalite and

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* Special experiments conducted in order to choose material for the tubes (X-raying empty tubes of celluloid and collodion) showed that celluloid is suitable for our purposes.

tridimite planes (table), it becomes evident that the calcined B silicagels (sample 5) is a mixture of β-cristobalite and β-tridimite. Uncalcined silicagels dried at room temperature contain crystallites of the same substances.

The exograph of the silicic acid gel, containing an admixture of 10% $CuCl_2$ (sample 7), is analogous to the exograph of the pure gel: the number of rings and their positions are identical. The exograph of the gel containing an admixture of $CuCl_2$ calcined (sample 8) differs from the same sample, not calcined: only two rings may be observed, and the dispersion angle corresponding to the second Debye ring is entirely different. The exograph of the silicic acid gel containing an admixture of 10% $BaCl_2$ (sample 6) differs from the exograph of the corresponding pure gel. There appear three distinct, comparatively narrower Debye rings which characterize a great degree of crystallization. The nature of the influence of $BaCl_2$ on the crystallization of the silicagel may be determined by more detailed study.

Conclusions

1. Silicic acid gels obtained from pure sodium silicate and silicon tetrachloride, differing in pH value and dried at room temperature, are of identical molecular structure. They contain crystallites of β-crlstobalite and tridimite of dimensions $<10^{-5}$ cm.

2. The pure gel may be transformed into a typically crystalline substance at as low a temperature as 900—950°. The calcined gel obtained from silicon tetrachloride is a mixture of β-cristobalite and tridimite. Heating to 800° results in the disappearance of diffraction rings on the exographs.

3. An admixture of 10% $CuCl_2$ in the silicic acid gels does not cause any change in its molecular structure. The presence of an admixture of 10% $BaCl_2$ in the gel makes it crystallize further. The mechanism of the influence displayed by $BaCl_2$ has not yet been made clear.

In concluding thanks are due to I. V. Grebenščikov for having suggested the subject of the present work, and to A. A. Lebedev and V. P. Buksheev for their valuable advices.

Section of Technical Sciences.
Group of Technical Chemistry.
Academy of Sciences of the USSR.

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CHEMISTRY

VISCOSIMETRIC STUDY OF KOUMISS

By I. F. BOGDANOV

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Koumiss is well known as a curative beverage prepared from mare's milk. Old koumiss is added to sweet milk in order to produce fermentation. The protein of the milk curdles under the influence of the acid from the rennet to form minute soft flakes settling slowly at the bottom of the vessel, while the bacteria of lactic and alcoholic fermentation, once introduced into nutrient medium with the rennet, commence propagating intensely and cause the fermentation of lactose sugar. The product is bottled after being agitated for 40—80 min. and seasoned in ice for 6—12 hours, whereupon it is ready for use.

Notwithstanding numerous investigations, the appraisement of koumiss is still based on personal judgment. It was of interest to clear up the question whether the quality of koumiss may be tested on the basis of its viscosity constant, since this method proved of great value for appraisement of lubricating oils, cellulose solutions, condensed milk, etc.

The determinations of viscosity were carried out in an Ostwald viscosimeter, the time of effluxion of 5 ml of water at 20° in the latter being 56 sec. The presence of suspended protein did not interfere with determination. In the case of koumiss the differences in the readings of time varied from 0.2 to 0.4 sec. This may possibly be explained by the minute dimensions of protein particles which do not obstruct the passage of the suspension through the capillary. Whatever truth there is in this supposition, the fact is that koumiss goes through a glass filter № 1, while on it being filtered through № 2 the entire protein is detained. The diameters of protein particles range therefore from 75 to 100 μ.

The results of the determinations of viscosity are given in Table 1.

As it will be seen, the viscosity of cow's and goat's milk is respectively higher by 33 and 40% than that of mare's milk. Still greater is the viscosity of the koumiss which exceeds that of milk by 51% for a young koumiss and by 61% for an old rennet.

The question arose, what causes might be responsible for so great an increase in the viscosity of koumiss compared to that of the initial milk. With an object to ascertain this problem, a comparative determination of the viscosities of koumiss and its filtrate was carried out after the removal of suspended protein by filtering it off on a Büchner funnel through a paper filter under suction. The same was performed with milk after curdling its protein by means of 2 ml of lactic acid added to 100 ml of milk. The filtration of the

Table 1

Constants of Koumiss and Various Kinds of Milk

Product	Acidity by Turner *	Density at 20°	Time of effluxion at 20° in sec.	Viscosity at 20° in centipoises ($100\,\eta$)	Relative increase in viscosity in %	Fluidity $\frac{1}{\eta}$
Mare's milk	4.5	1.036	75.2	1.391	0	71.9
Cow's milk	17.0	1.033	99.5	1.850	33	54.1
Goat's milk	—	1.029	105.5	1.940	39.5	51.6
Koumiss	72.5	1.027	114.6	2.100	51	47.6
Rennet (old koumiss)	176.0	1.010	124.2	2.240	61	44.5

* Number of ml of 0.1 *N* solution of NaOH used to titrate 100 ml of material.

rennet was substituted by centrifuging, which is apt to produce the same effect. The results are given in Table 2.

Table 2

Alteration in Viscosity of Koumiss and Milk after Filtration

Product	Density at 20°	Time of effluxion at 20° in sec.	Viscosity at 20° in centipoises ($100\,\eta$)	Relative decrease of viscosity in %	Fluidity $\frac{1}{\eta}$
Milk	1.033	75.8	1.410	0	70.8
Milk filtrate	1.032	71.8	1.334	5.4	74.8
Koumiss	1.023	116.6	2.130	0	46.9
Koumiss filtrate	1.021	71.0	1.294	39	77.3
Rennet (koumiss)	1.008	119.7	2.150	0	46.4
Rennet (koumiss) centrifugate	1.007	71.7	1.300	39.5	76.8

The most important conclusion to be drawn from this table is the fact that the filtrates from koumiss and milk and the centrifugate from rennet show nearly the same values of viscosity. The latter in filtrate from milk was only by 5.4% lower than in the milk itself. Thus, the removal of protein from mare's milk, where it had been previously dissolved, tells but little on the decrease of viscosity of the product, while in the case of koumiss the decrease reaches 39%. The high value of viscosity of koumiss should, therefore, be put down to the protein suspension alone.

Since the internal friction of the koumiss depends on the suspended protein, it was important to establish whether or no the value of viscosity is dependent on the amount of suspended protein. The mathematical relationship between the viscosity of suspensions and the concentration of suspended material has first been expressed by Einstein [1] in the form of the following equation: $\eta_s = \eta_0\ (1 + 2.5\ \varphi)$, where η_0 is the viscosity of the medium, and φ — ratio of the volume of dispersed material to the total volume. However, the application of that equation to the case of protein substances was not crowned with favourable results. Empiric equations have been proposed, consequently, by some of the authors, as Arrhenius, Hess, Hatschek [3] etc., for the suspensions studied by them.

To find out whether these equations are valid in the case of koumiss, the determinations of viscosity and concentration of suspended protein have been carried out on various samples. The volume of suspended protein was readily found by centrifuging the koumiss for 5—10 min. in a Gerber hand-centrifuge. The calculations showed that the experimental data are in no good agreement with the formula of Einstein and with other equations. The equation of Hatschek (2) $\eta_s = \frac{\eta_0}{1 - \sqrt[3]{\varphi}}$ gave somewhat better results. Upon further examination of the results it was shown that the relation between the viscosity of koumiss at 25° and the amount of suspended protein is satisfactorily expressed by the following simple equation: $\eta = \frac{1}{1 - \sqrt[3]{\varphi}}$. Some data are given in Table 3 to illustrate the validity of this equation.

Table 3

Relation between the Viscosity of Koumiss and the Concentration of Protein Suspended in It

Product	Density	φ	Viscosity at 25°		Difference, %
			Found	Calculated	
Rennet	1.0213	0.09	1.808	1.812	+ 0.2
Mixture (milk + rennet)	1.0290	0.12	2.034	1.972	— 3.0
Koumiss sample I . .	1.0236	0.09	1.781	1.812	+ 1.7
» » II . .	1.0266	0.11	1.924	1.920	— 0.2
» » III . .	1.0253	0.12	1.970	1.972	+ 0.1
» » IV . .	1.0266	0.85	1.744	1.757	+ 0.7

In all cases except that of the mixture the calculated values approached the experimental ones. Hence, the viscosity of koumiss being known, a conclusion can be drawn on the amount of suspended protein and, vice versa, the viscosity of the product may be easily calculated from the amount of protein determined by centrifuging.

The viscosity or its reciprocal—fluidity—as well as the relative amount of suspended protein prove therefore to be very good indices of the quality of koumiss and can be used for appraising the latter. The more so, as the viscosity of koumiss is largely dependent on the method of its preparation, as it was shown by experiments. Koumiss prepared without gradual development possessed a high viscosity, while the developed one, i. e. prepared by means of prolonged agitation at a high acidity of the preparation, showed but a small amount of suspended protein (5—7% by volume) and a low viscosity. Add to this that the value of viscosity (or fluidity) differs from the other constants by its exceptional stability for the sample concerned, being slightly changeable on preservation, and it will be obvious that we have sufficient ground to propose it as one of the standard indices for testing koumiss.

Biochemical Laboratory.
Shafranov Health Resort.

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CHEMISTRY

ON DISPERSION OF PLATINUM CATALYSTS

By A. M. RUBINSTEIN

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Different preparations of platinum have been used for the study of catalytic reactions and phenomena since the doctrine of catalysis came into being, i. e. from the times of Davy, Döbereiner and Berzelius. Most of the investigations dealing with catalysis on platinum were devoted to the kinetics and the mechanism of the reactions, and only in a few of them the structure of the catalysts and its relation to their properties were studied.

Notwithstanding the small number of papers of the latter kind, some very interesting results have been obtained. Thus, Clark (1) was the first to point out the non-monotonous change in the activity of platinum catalysts with the increase of the degree of dispersion. Quantitatively this was demonstrated by Levy and Haardt (2) in their study on the decomposition of H_2O_2 in the presence of different samples of platinum, prepared by different methods. The dispersion of preparations studied by them varied from 4.8 to 11. 27 μμ (48—112.7 Å). These authors found also that the catalytic activity increased with the growth of the specific area, rapidly at first and then more slowly. When the specific area had reached the order of 3000 cm^2 per 0.01 g of Pt, the velocity of the reaction became constant. Dankov and Kochetkov (3) prepared a sample of platinum having a high degree of dispersion, i. e. about 25 Å, by using a special method of preparation. The activity of this sample, as well as some others (dispersion 40—50 Å), was tested on the reaction of the hydrogenation of ethylene. Using their own data, as well as extrapolating the data of Levy and Haardt, Dankov and Kochetkov obtained a curve of relationship of platinum activity to the degree of dispersion, which had a peaked maximum in the area of 40—50 Å. The left branch of the curve dropped rapidly, the zero activity lie within the area of about 20 Å.

Bredig and Allolio (4) studied metals atomized from the cathode and found that Pt obtained in this way was inactive on the hydrogenation of ethylene at low temperatures. They connected this phenomenon with the expansion of the space lattice of the Pt crystal as a result of the intrusion of hydrogen into it. An opposite influence of the adsorption film on the activity was demonstrated by Ablesova and Roguinsky (5) who obtained preparations of Pt, Ni and Cu by evaporating trained and untrained metals in vacuo. Using preparations of the same degree of dispersion, Taylor, Kistiakovsky and Perry (6) have demonstrated that for reactions of oxidation $CO \rightarrow CO_2$ and $SO_2 \rightarrow SO_3$ and of hydrogenation of ethylene the results obtained for the former two reactions coincide with each other, while those obtained for the latter differ from them. The activity, therefore, depends upon the type of the reaction.

Taking into consideration that in the case of catalysis in organic chemistry platinum ordinarily is being used on a carrier, the author considered it expedient to determine the structure of this kind of preparations. Three preparations of platinum on activated charcoal and one preparation of platinum on aluminium oxide were studied.

Platinum on aluminium oxide was prepared by impregnating Al_2O_3 with hydrochloroplatinic acid, decomposing it by heating and reducing with hydrogen (7). The preparations consisting of platinum deposited on activated charcoal were obtained in the following manner: one was obtained by

precipitating the metal by means of formaldehyde in alkali solution ([7]), the other two—by decomposing hydrochloroplatinic acid on charcoal through heating it in an atmosphere of hydrogen.

The first two catalysts have been studied in the parallel dehydrogenation and dehydration of alcohol ([7]). Both of them were not very active up to 260°. In the interval from 180 to 260° nickel on aluminium oxide proved to be more active, as it may be seen from Table 1 (the relative activity is expressed as percentage of the alcohol that underwent reaction).

Table 1

Relative Activity of Nickel and Platinum Catalysts

Catalyst / $T°$, C°	Pt—C	Pt—Al_2O_3	Ni—Al_2O_3 No 12	Ni—Al_2O_3 No 13	Ni—Al_2O_3 No 14	Ni—Al_2O_3 No 17
180	12.5	6.0	23.1	20.3	16.5	9.0
200	12.7	6.0	36.8	33.5	41.5	11.1
220	17.5	6.7	52.7	96.2	64.5	19.2
240	25.3	17.6	100.0	100.0	87.9	27.2
260	36.7	21.2	100.0	100.0	100.0	50.8
280	50.0	46.8	—	—	—	—
300	59.4	75.8	—	—	—	—

In the interval from 260 to 280° a considerable increase in the activity of both platinum catalysts was observed. The Pt—Al_2O_3 catalyst proved to be more active, when the temperature was further raised to 300°.

The structure of the catalysts was determined by means of X-ray photography. The corresponding Debye diagrams are shown in Figure 1. The X-ray diagrams were obtained without a filter with an iron anticathode at 10 mA and 35 kV. The exposition lasted from 7 to 9 hours. On the X-ray diagram of Pt—Al_2O_3 the interference lines of both components are to be found. On the X-ray diagram of Pt—C catalysts lines of platinum only may be observed, as it will be obvious from comparing these X-ray diagrams to the diagram of Pt—wire. Carbon lines are absent. The paremeters of the unit cell of the space lattice and the dispersion (length of the crystal edge) have been determined on the base of the X-ray diagrams. The results are shown in Table 2.

Table 2

Catalyst	Parameter a, Å	Dispersion, Å
Pt—Al_2O_3	3.904	38.6
Pt—C, deposited with HC(=O)H	3.900	25.8
Pt—C decomposition of H_2PtCl_6 by heating	3.861	26.8
	3.860	27.0

The parameter values for pure platinum (a cubic unit cell with centered facets) is a=3.905*, according to the data of precise measurements. Thus, the discord in values obtained for the first two preparations lie within the limits of experimental error. For platinum on charcoal, prepared by thermal decomposition of H_2PtCl_6 on charcoal, the discord is already considerable. This is probably a result of particularities of the reduction (the latter—by carbon, the former two—by hydrogen). The greater activity of preparations obtained by thermal decomposition seems to depend upon the slightly abnormal structure of the platinum unit cell, as the degree of dispersion of all Pt preparations was of the same order.

* Landolt-Börnstein, Physikal. Chem. Tab., II Ergzgsbd. 596.

The degree of dispersion of platinum was determined by treating the microphotometer curves obtained from X-ray diagrams on a Koch and Guss recording microphotometer. In Fig. 2 two such curves are shown, taken with a twofold magnification. From the breadth of the lines between the points, where the intensity equals one half of the maximum one (Halbwertsbreite), the dispersion has been calculated by the Brill ([8]) method and by using his curves.

A comparison of the data available on the dispersion of platinum catalysts showed that the method of preparation was one of the main factors

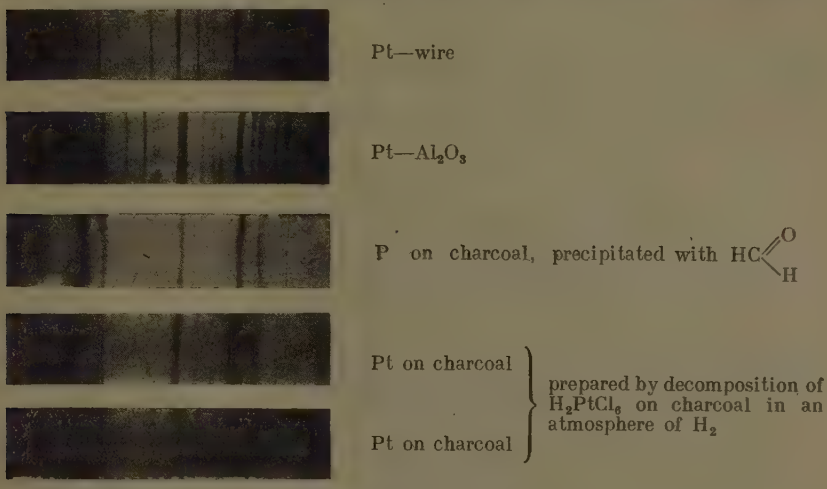

Fig. 1. Debye diagrams of Pt catalysts.

which determined the size of the primary crystals (Table 3). Next to this factor the nature of the carrier has considerable influence on the degree of dispersion, as it may be seen from the fact that all platinum preparations on charcoal obtained by different methods show practically the same degree of dispersion.

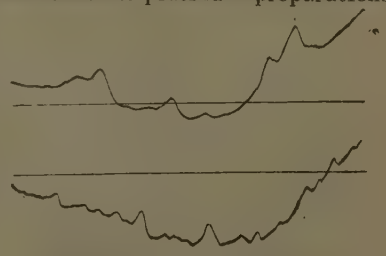

Fig. 2. Above—Pt on charcoal, below—Pt—Al_2O_3.

It is necessary to point out that the data obtained showed the possibility of preparing platinum of a high degree of dispersion at temperatures higher than those mentioned by Dankov and Kochetkov ([3]) (Table 3, № 6—7 and 9—10). In this case, no doubt, recrystallization is strongly retarded and that is the reason why catalysts on carriers are sufficiently stable. On the other hand, the discovery of the low activity of Pt—Al_2O_3 and Pt—C catalysts agrees well with the general relationship between activity and the degree of dispersion in the case of non-mixed catalysts, which was established by Dankov and Kochetkov on the base of their own data as well as of the data found in the literature. The degree of dispersion of preparations having a normal structure of the unit cell, studied by the author, lies within the area close to zero activity. A higher activity of platinum preparations on charcoal obtained by thermal decomposition of H_2PtCl_6 should, probably, be ascribed

to the abnormal position of the atoms in the space lattice of the crystal. What influence has the nature of the carrier on the deformation of the lattice was pointed out by Thomson (9) on the basis of data obtained with different carriers: copper, asbestos, etc. A higher activity of catalysts having an abnormal lattice ensues also from physico-chemical theories of catalysis.

The results obtained by the author on determining the degree of dispersion and the activity of platinum catalysts go to confirm the existence of an optimal degree of dispersion for mixed catalysts. The character of the curves expressing the relation of activity to the degree of dispersion is specific for each kind of catalyst. This may be observed by comparing the activity dis-

Table 3

Dispersion of Platinum Preparations Obtained by Different Methods

No	Catalyst	Method of preparation	Dispersion	Author
1	Pt—black of Cereus	—	69.3 Å	Levy and Haardt
2	Pt—black	Precipitated in the cold from a 5% solution of H_2PtCl_6 by aluminium shavings	48.0 Å	
3	Pt—black	Precipitated by heating with aluminium from an acid solution of H_2PtCl_6	52.8 Å	
4	Spongy Pt	Obtained by decomposition of $(NH_4)_2PtCl_6$ at 320°	112.7 Å	
5	Spongy Pt	As the former one, but heated once more at 250°	90 Å	
6	Pt—black	According to Feilgen, but at a $T°$ lower than—5°C	25—30 Å	G.D. Dankov and A.A. Kochetkov
7	Pt—black	According to Feilgen, but at a $T°$ from 0 to 5°	40 Å	
8	$Pt—Al_2O_3$	By thermal decomposition of H_2PtCl_6 on Al_2O_3 and reduction with H_2	38 Å	
9	Pt on charcoal	Precipitated by $HC\langle^{O}_{H}$ in alkali solution	26.8 Å	A.M. Rubinstein
10	Pt on charcoal	By thermal decomposition of H_2PtCl_6 on activated charcoal	27 Å (26.8 Å and 27 Å)	

persion curve for platinum (3) with the activity dispersion isotherms for nickel-alumina catalysts used for the dehydrogenation of alcohol (10). In the latter case the curves based on experimental data (without extrapolation) have a much less peaked, but still clearly pronounced optimum.

Institute of Organic Chemistry.
Academy of Sciences of the USSR.

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CHEMISTRY

AN ATTEMPT TO PREPARE SOME NEW ANTIMALARIAL COMPOUNDS

By N. S. DROSDOV and V. I. STAVROVSKAJA

(Communicated by N. D. Zelinsky, Member of the Academy, 4. II. 1939)

It is among the derivatives of quinoline and acridine (1) that the compounds most active against the causal agents of malaria have been discovered. The researches undertaken by various investigators who aimed at discovering antimalarial compounds relate, therefore, mainly to the studies of various heterocyclic compounds. There are known only solitary attempts to discover some compounds effective against malaria among the derivatives of benzene and naphthalene. Most of those attempts resulted in obtaining inactive compounds.

E. Fourneau succeeded, nevertheless, in discovering among a great number of compounds, prepared by him, some derivatives of benzene and naphthalene endowed with appreciable effectiveness with regard to malaria of birds(2). Recently, W. Yorke (3) has shown that such compounds as, for instance, undecan-1,11-diamidine are apt to produce an unmistakable influence on experimental tripanosomoses and malaria of man (*Pl. vivax*). His results leave no doubt as to the possibility of obtaining compounds effective in the case of malaria, which do not belong to heterocyclic series.

A great interest in sulphone-amide derivatives which became remarkable within recent years is due to the fact that many of them have proved of high effectiveness in controlling some bacterial infections. Several investigators have, therefore, up to the present day confined their researches in this field to preparing sulphone-amide compounds endowed with the power to control diseases caused by various cocci(4).

Considerable and quite independent interest is due, however, to an investigation which would have for object to obtain sulphone-amide compounds effective in the case of protozoa infections. Special attention should be paid to a preparation of various dialkylamino-alkyl derivatives of *p*-aminobenzene-sulphone-amide and other similar compounds, whose structure would permit us to expect from them a controlling influence on the causal agents of malaria. Such a problem seems the more actual as several papers have appeared abroad, in which an appreciable effect of *p*-aminobenzene-sulphone-amide and 4'-sulphone-amide-2.4-diaminoazobenzene on some forms of human malaria (5) is reported.

These reasons prompted the authors to prepare the following compounds: phenyl-γ-diethylaminopropylamine

$$C_6H_5 \cdot NH \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot N(C_2H_5)_2,$$

benzyl-δ-diethylamino-α-methylbutylamine

$$C_6H_5 \cdot CH_2 \cdot NH \cdot CH(CH_3) \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot N(C_2H_5)_2,$$

the derivatives of 4-aminobenzene-sulphone-amide of a general formula

[where R′ is $-CH_2 \cdot CHOH \cdot CH_2 \cdot N: C_5H_{10}$, $-CH_2 \cdot CHOH \cdot CH_2 \cdot N(C_2H_5)_2$, $-CH(CH_3)CH_2 \cdot CH_2 \cdot CH_2 \cdot N(C_2H_5)_2$ or H]:

4-acetoaminobenzene-(γ-piperidino-β-oxypropyl)-sulphone-amide

[R=CH_3CO-],

4-aminobenzene-(γ-piperidino-β-oxypropyl)-sulphone-amide

[R=H],

4-acetoaminobenzene-(γ-diethylamino-β-oxypropyl)-sulphone-amide

[R=$CH_3 \cdot CO-$],

4-aminobenzene-(γ-diethylamino-β-oxypropyl)-sulphone-amide

[R=H],

4-acetoaminobenzene-(δ-diethylamino-α-methyl)-sulphone-amide

[R=$CH_3 \cdot CO-$],

4-aminobenzene-(δ-diethylamino-α-methylbutyl)-sulphone-amide

[R=H],

4-(4′-aceto-aminobenzene-sulphone-amido)-benzene-(δ-diethylamino-α-methylbutyl)-sulphone-amide

[R=$CH_3CO \cdot HN \cdot C_6H_4 \cdot SO_2-$],

4-(γ-diethylaminopropyl)-amino-benzene-sulphone-amide

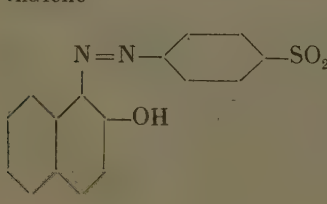
[R=$(C_2H_5)_2N \cdot CH_2 \cdot CH_2 \cdot CH_2-$],

4-(γ-diethylaminopropyl)-amino-benzene-(δ-diethylamino-α-methylbutyl)-sulphone-amide

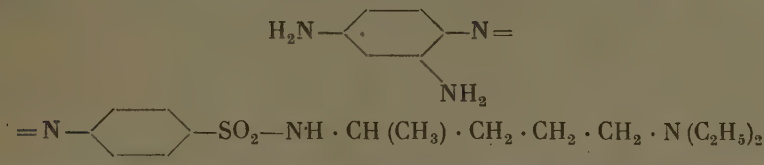
[R=$(C_2H_5)_2N \cdot CH_2 \cdot CH_2 \cdot CH_2-$],

and azocompounds:

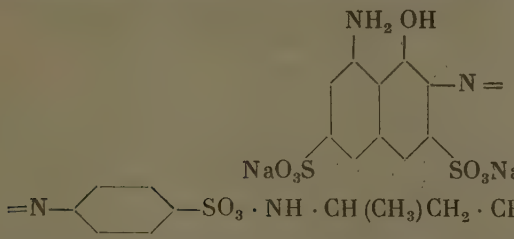
4′-(δ-diethylamine-α-methylbutyl)-sulphone-amidobenzeneazo-2-oxynaphthalene



4′-(δ-diethylamino-α-methylbutyl)-sulphone-amide-2.4-diaminoazobenzene



and disodium salt of 4′-(δ-diethylamino-α-methylbutyl)-sulphone-amide-benzeneazo-1-oxy-8-amino-3.6-naphthalene-disulphonic acid



All of these compounds failed to produce any appreciable positive effect when tested on the malaria of birds at the Laboratory of Protozoa Section of the Tropical Institute. Thus, the experimental results seem to testify against the compounds obtained as regards to their antimalarial qualities. One should not forget, however, that arsenic compounds, as stovarsol for instance, have long been known (6) to reveal different attitude towards the malaria of man and that of birds, and it is highly probable that the sulphone-amide compounds closely resemble the arsenic compounds in their behaviour. This is the reason for expecting the same variable effect from the compounds prepared by the author. The results obtained by testing these compounds on malaria of birds have, therefore, to be regarded as a first stage in the study of their antimalarial qualities.

Conclusions

Several new dialkyl-amino-alkylderivatives of *p*-amino-benzene-sulphone-amide and some azocompounds have been prepared in order to obtain antimalarial compounds.

Laboratory of Organic Synthesis.
Tropical Institute.
Moscow.

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BIOGEOCHEMISTRY

GEOCHEMICAL INVESTIGATIONS ON THE SPREADING OF THE UROV ENDEMY

By A. P. VINOGRADOV

(Communicated by W. I. Vernadsky, Member of the Academy, 10. II. 1939)

The Urov disease in the human organism originates in the period of childhood; it affects the skeleton, producing a deformation of bones, contractions of the joints, etc., and the organism of the person attacked becomes one of abnormal development. For the first time this endemy was discovered in the fifties of the last century; then it was described in detail by Kashin, studied by Beck and others. During the recent years it has been systematically studied from the medical standpoint at the Urov Institute on the Jamkun(1).

The Urov disease is endemic for the region located in Eastern Transbaikalia between the Shilka (the northern boundary of the endemy), the Argun (the eastern boundary) and the Nijnaja Borzya and the Unda rivers (in the west). The central and eastern parts of the region are of a mountainous-taiga nature. The woody ridges are here the watersheds of the Argun, Urov, Uryumkan and Gazimur rivers, into which numerous tributaries are flowing through swampy valley. The south-western boundary passes into a steppe. The region is located within the belt of permanently frozen grounds. The whole region of the endemy is characterized by young relief and soil. Here old massive rocks are widely developed, while post-Tertiary formations are nearly absent. The sedimentary rocks, particularly the old limestones frequently in the form of marbles, as a result of an erosion that took place in the past, have been preserved only as small patches.

Japanese authors described cases analogous to the Urov disease from Manchuria and Corea which enables us to presume the spreading of this endemy in the countries named, outside the USSR.

Most of the investigators engaged in the study of the Urov disease consider it now as due to an exogenic factor which, though not definitely established, is supposed to be present in the waters of the region mentioned. On the basis of this assumption many authors have advanced a number of hypotheses explaining the origin of the endemy by the content of gold or cadmium in the waters of the region, while others explained it by the presence of lead etc., or lack of iodine, excess of calcium, iron, sulphur, etc. However, all of these hypotheses, as it will be shown later, are not supported by facts and are at the best only unfounded statements.

A closer acquaintance with the nature of the Urov endemy has shown that it has many of those features of endemies which we call biogeochemical ones and which are primarily related to the deficiency or excess of some or other chemical elements in the environment (2). It should be added that parallel to the Urov endemy in this region are spread: 1) endemic rickets of children; 2) endemic goitre in men and animals; 3) brittle of bones of animals («osteoporosis»). The features of the latter endemy have been known for a long time;

however, we have paid attention to the probability of its extensive development after having obtained low data for the calcium content in the grasses of this region. All this induced the author to start in his investigation with the analysis of the waters of this region, the more so that no quantitative data on their composition were available. Below a short summary of data will be given, obtained by the author at the Biogeochemical Laboratory of the Academy of Sciences of the USSR during 1935—1937*; the full material is intended for later publication(3).

Up to 70 samples of potable water from 42 different places of the region have been studied, nearly half of them being taken from places with a population affected by the Urov endemy (conventionally «affected» waters) and the rest from healthy localities («healthy» waters, respectively). Water used by the population for drinking purposes is that of rivers, rivulets, springs, from under the frozen ground included, and that from fissures in massive rocks. The samples were taken in the summer (June-July). The temperature of the water in the springs is usually 0.2—4°C. The waters are clear; sometimes they have a pronounced coloration due to organic substances (the influence of swamps). The coloration was observed both in «affected» and «healthy» waters, e. g. in the «healthy» waters of the Mikhailovskaya, Choldon and other rivers, and inversely, the «affected» springs have no coloration, e. g. the Patrino spring, like the majority of «healthy» waters. The waters of the local rivers are oxidulated, containing on the average nearly 7 mg O_2 per litre; those in the springs contain less than 1 mg O_2 per litre. «Healthy» and «affected» rivers are not sharply distinguishable as to their content of oxygen. The NO_2, NO, NH_3 content presents no peculiar features. The iodine content in the water of the Bunia, Zola, Urov etc., along the course of which endemic goitre is spread among the population, is about $0.47 \cdot 10^{-7}\%$; in the water of the Borzya, Kurenga etc., where there are either no cases of goitre or few, the content of iodine amounts to $2.84 \cdot 10^{-7}\%$. The bromine content ranged between $1.25 \cdot 10^{-6}$ and $1.7 \cdot 10^{-7}\%$. The fluorine content varied from $5 \cdot 10^{-6}\%$ to $2.4 \cdot 10^{-5}\%$ which is usual for many waters of the Union (4). The occurrence of phosphorus, boron, radium in the waters gave nothing unusual. A number of «affected» waters are lacking in gold ($10^{-6}\%$). Zirconium, copper, titanium, aluminium etc. were found to be present in equal ratios as they are in the water of Moskva-river. Cadmium and a number of other chemical elements have not been detected. Lead and molybdenum in some waters showed a higher content than that usually found in fresh waters, which fact, however, was not definitely related to the endemy. Strontium constitutes 0.5—1.0% of the calcium of the water, i. e. its average ratio is about $n \cdot 10^{-5}\%$. Its distribution in the waters of the Urov region presents a highly variable picture**. The content of alkaline-earth elements, in the first instance of calcium, is considerably lower in «affected» than in «healthy» waters. The same is true of the total content of salts in the waters analyzed. On the content of other chemical elements in «affected» and «healthy» waters an idea is given by the following average data (in weight per cent).

It will be obvious that «affected» waters are characterized by a very low mineralization, particularly by a low calcium content (occasionally below $3 \cdot 10^{-4}\%$), and a high content (namely, in the waters of swamp rivers) of organic matter. By way of example the calcium content in two neighbouring villages, located some km apart respectively, will be given [one of the villages being attacked by the disease («affected») and the other «healthy»].

* In the expedition collection and study of the material the following workers of the Biogeochemical Laboratory participated: T. F. Borovik-Romanova, V. S. Malinina, V. M. Ratynsky, K. P. Florensky, S. A. Borovick, M. A. Dragomirova and others.

** I hope to return to the problem of Sr distribution in waters in the near future.

	Dry residue	Residue after calcination	Loss on calcination	SiO_2	Ca
Waters chiefly from healthy places of the endemic region (from 21 villages)	$3.18 \cdot 10^{-2}$	$1.74 \cdot 10^{-2}$	$1.44 \cdot 10^{-2}$	$1.27 \cdot 10^{-3}$	$4.36 \cdot 10^{-3}$
Waters chiefly from attacked places of the endemic region (from 21 villages)	$1.17 \cdot 10^{-2}$	$6.95 \cdot 10^{-3}$	$4.75 \cdot 10^{-3}$	$1.15 \cdot 10^{-3}$	$1.80 \cdot 10^{-3}$

	Mg	HCO_3'	Fe	Cl	SO_4
Waters chiefly from healthy places of the endemic region (from 21 villages)	$2.51 \cdot 10^{-3}$	$2.25 \cdot 10^{-2}$	$1.14 \cdot 10^{-5}$	$5.63 \cdot 10^{-5}$	$1.79 \cdot 10^{-3}$
Waters chiefly from attacked places of the endemic region (from 21 villages)	$6.54 \cdot 10^{-4}$	$1.03 \cdot 10^{-2}$	$4.25 \cdot 10^{-5}$	$3.24 \cdot 10^{-5}$	$8.33 \cdot 10^{-4}$

«Affected»		«Healthy»	
Sivachi (water of the Urov r.)	$2 \cdot 10^{-3}$% Ca	Urov springs	$5.2 \cdot 10^{-3}$% Ca
Alashiri (water of the Urov r.)	$1.7 \cdot 10^{-3}$% Ca	Talakan (springs)	$4.7 \cdot 10^{-3}$% Ca
Patrino (spring)	$0.3 \cdot 10^{-3}$% Ca	Georghievskoye (river) . . .	$5.0 \cdot 10^{-3}$% Ca
Sergeevka (the N. Borzya river)	$0.8 \cdot 10^{-3}$% Ca	Chuprovo (spring)	$4.2 \cdot 10^{-3}$% Ca
Turov (near the Turov river)	$0.8 \cdot 10^{-3}$% Ca	Tontoy (the Choldon river)	$6.1 \cdot 10^{-3}$% Ca

Attention should be paid to the fact that not only in the rivers, but in the springs as well, the «affected» waters have proved to be poorly mineralized and possess a low content of Ca. The case is reverse with «healthy» waters of rivers and springs.

The lowest mineralization of waters (and calcium content) in the upper courses of rivulets of the II and III order (on a local scale), e. g. Motogor, Alashiri, Sivachi and many others, is to $n \cdot 10^{-4}$% calcium. In the lower courses of these rivers and in the rivers of the I order—the Urov, Gazimur and others—the calcium content is somewhat higher, about $2 \cdot 10^{-3}$%Ca. It is with these rivers that the villages attacked by the Urov endemy are connected. It is of interest to note here that according to the observations of the Urov Institute, the gravity of the endemy in villages increases from the mouths of the rivers towards their upper courses, i. e. in inverse proportion to the calcium content in water. The waters from the Kurenga, Borzya, Choldon, Mikhailovskaya rivers, as well as those from the «healthy» springs, contain usual and even higher amounts of calcium. Viewed with reference to their position on the geological map of the region, the «healthy» villages and towns, as Nerchinsky Zavod, Kadaya, Georghievskoye, Talakan, Urovskie Klyuchi (springs), Serghievskoye and many others, prove to lie within the zone of development of limestone patches. Their healthy population uses, as shown by our data, hard water. On the contrary, the attacked villages lie in the areas of development of massive rocks (igneous basalts, granites, as well as metamorphozed slates etc.), and their population uses soft water. Noteworthy, in this connexion is the fact that no cases of Urov disease have been recorded among the workers of the local lead deposits, since such deposits are known to be usually situated in limestones.

A low calcium ratio in a river indicates either its small amount or poor solubility of its compounds in water throughout the drainage area or basin

of the river concerned. The deficiency of calcium in the endemic region is testified also by the analyses of the grassy vegetation. Thus, e. g., the hay from the healthy (with regard to the osteoporosis of animals) places contains about 0.5% P_2O_5 and about 1.0% CaO by dry weight, while for attacked ones (with respect to osteoporosis) the average from numerous data is $P_2O_5 < 0.2\%$ and $CaO < 0.5\%$. The hay from different places of the Urov region on the average gave 0.48% P_2O_5 and $< 0.50\%$ CaO. The bones of people suffering from the Urov disease, according to the author's analyses, contained less phosphorus and calcium than the bones of healthy persons from the same region.

The nature of the food used by the population of the endemic region goes only to aggravate the deficiency of calcium in the organism. Vegetables and fruit are not in general use in the region of the endemy. The cattle seem to give little milk which, in turn, may possibly stand in relation with a deficiency of mineral supply. The population has some peculiarities in its use of milk. In summer they go to water-meadows to mow, using the local water of rivers and springs. In winter ice is rather widely used (i. e. practically distilled water), since many rivulets freeze down to the bottom. All this may disturb and pervert the calcium exchange of a man.

The deficiency of calcium in the food of the cattle or the disturbance of the Ca/P ratio is known to produce a disease, manifested in the brittle of bones in animals called «osteoporosis» etc. This disease persists up to now in many localities of all countries. In this respect the region of the Urov endemy, probably, presents no exception.

Considerably more complicated is the question as to the possibility of the existence of an endemic disease of people in some way connected with the deficiency of calcium in food, etc. The deficiency of calcium in food is a factor in the origin of rickets. The endemy of osteomalacia in India, Central China and other places is connected with poor content of calcium in the food (and with a relatively high phosphorus content).

The fact that the healthy villages are confined to the areas of development of limestones, the use of hard water and conversely, the position of the attacked villages (sometimes side by side with the healthy ones, which has always struck the investigator) outside the areas of development of limestones, the use of soft waters, on the one hand, and the existence of rickets in people and brittle of bones in animals, on the other, lead us to the conclusion that the deficiency of calcium (considering the nature of the local rickets, frozen grounds and other factors) plays an important part in the pathogenesis of the Urov disease. The same cause seems to be responsible for a peculiar disease of the local cattle, manifested in the brittle of bones.

The implication of the present work is that it is time to take definite measures for controlling the endemies of this region.

Biogeochemical Laboratory.
Academy of Sciences of the USSR.

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GEOLOGY

SHOWINGS OF GAS IN THE LOWER NIMAN REGION

By N. A. NATIS

(Communicated by W. A. Obruchev, Member of the Academy, 16. II. 1939)

The Lower Niman area of the Far-East region, where showings of gas have been first detected, is a mountainous country of medium altitudes, known under the name of the Turan range. The relative elevation of the watersheds over the valleys reaches up to 200—400 m with absolute marks at 700—900 m. The peculiarities of the relief are strictly concordant with the geological structure, namely a sharp dissection of the relief is observed in the most stable rocks composing the gorge «Corridor» at the Niman river (figure), and a considerable subsidence of the watersheds of the southern portion of the region, which may be accounted for by a replacement of the massive crystalline rocks by a sedimentary series of the Mesozoic (Jurassic).

The area under description is located within the lower course of the Niman river, the right-hand tributary of the Bureya river (the Amur river basin), where frozen ground is supposed to be spread over the whole area. The upper boundary of the frozen ground is lying at different depths. In the lower portions of the relief it is lying 0.6—1.5 m from the surface, while in the more elevated portions covered with a thick layer of placers frozen ground is encountered at a depth of 5—10 m. It is hardly probable that frozen ground is lying as a solid impervious layer. Obviously, there are some places, where the continuity of the frozen stratum is broken by the discharge of water, issuing from great depths along plane fractures. The showings of gas seem to be connected with the presence of fractured zones in the region. That is why it is deemed necessary to give here some brief information as to the geology of the region.

Geology. The north-western part of the region, from the mouth of the Keveli river to the Corridor, is composed of the oldest rocks—gneisses and microcline-granites. The gneiss complex consists of highly altered schistose sedimentary formations—paragneisses and orthogneisses. The latter are younger formations and their occurrences among paragneisses have retained the shape of small intrusive bodies. All the tectonic lines of the rocks of this area are of a north-western strike.

The next in age are hornblende- and oligoclase-granites, diorites and gabbro-diorites; their massifs are formed by intrusions of different epochs, according to the geologist A. M. Mikhailov (3) who visited this region in 1934. The central portion of the region—the Niman Corridor—is composed chiefly of oligoclase granites and diorites and gabbro-diorites in smaller quanti-

ties. The contacts of these rocks have a north-eastern strike. The granites of the Corridor are mostly coarse-grained rocks of a pink and light-grey colour and of an ordinary composition; almost in all the granite thin-sections titanomagnetite is observed. Orthite is also frequently present in small rounded crystals surrounded by epidote. Apatite, sphene and zircon are found in small quantities. Orthite, apatite and zircon are encountered also in diorites and gabbro-diorites, but in smaller quantities than in granites.

Younger formations are shallow water sedimentary deposits belonging to the Jurassic. These are represented here chiefly by areno-argillaceous shales and sandstones, whose strata are slightly dislocated by later tectonic processes. The Jurassic beds are traced from the southern end of the Corridor up to the Bureya river; they are crumpled into folds with a NNE strike. Both in the Jurassic and in older rocks a clearly pronounced system of vertical fractures is observed in the same direction, penetrating to a considerable depth.

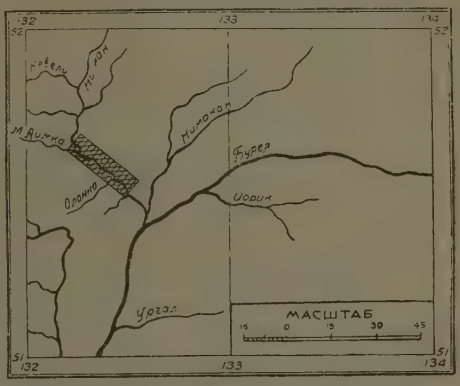

Fig. 1. Scheme of location of the area investigated (Niman Corridor shaded).

The whole post-Jurassic history of development of the region is accompanied by light tectonic movements of a disjunctive type, which are manifested in the formation of numerous fracture openings, along which the relative displacement of individual areas takes place. These disturbances take place over the whole area, but they are most clearly pronounced among the Jurassic rocks, owing to their being laminated.

The presence in the region of traces of an ancient terrace and a rejuvinated hydrographic network suggest that at present the activity of the tectonic processes did not cease; this is evidenced also by the observed earthquakes (4).

Showings of Gas. Gas issues are found in the Niman Corridor composed, as shown above, of biotite granites, diorites and gabbro-diorites, near the contact lines of the rocks.

The first issue of gas has been detected at the right-hand bank of the Niman river about 1.5 km down the Malaya Aimka river. The Niman river forms here a small bay—«the ulovo»»—in front of which the joints of porphyry-like granite stretch to the north-east and dip in a north-western direction (angle 60°). Along the line of strike of the fissure, at a distance of about 1 m from the line of water, a continuous issue of gases from the water was observed on August 12, 1934. The discharge of this gas issue is 0.6—0.7 liter per minute. The temperature of water in the river is + 19°C, the temperature of air is +20.5°C. During another visit to this place on September 30, 1934, the water level of the Niman River was lower than on August 12, and no gas issues were observed.

The second gas issue was detected at the bed of the Niman river near the southern end of the Corridor, approximately 25 km down the Malaya Aimka river. The water-side projections of country rocks are composed here of biotite granites. The № 1 gas sample has been taken from here (table).

The third gas issue at the bed of the Niman river is located at about 1 km up the mouth of the Olonka River (18 km down the Malaya Aimka river),

where the dominating joint place of diorite stretches to the north-east (60°), dipping north-westward at an angle of 45°. From here on August 5, 1934, the second gas sample was taken, admixed with a small amount of air.

An analysis of the gases made by A. A. Cherepennikov in the Gas Laboratory of the Central Scientific Research Geological Prospecting Institute showed the following composition:

Sample	Composition							Rare gases	
	H_2	H_2S	CH_4	O_2	CO_2	CO	N_2+rare gases	Heavy	Light
1	—	—	—	1.1	—	—	98.1	1.160	0.047
2	—	—	—	19.0	0.5	—	80.5	No made	

The similarity of these two analyses suggests that the third gas issue is of the same type as the first and second ones.

Thus, the gases of the Niman Corridor belong to the pure nitrogen stream type, enriched with light rare gases.

The absence of more or less considerable fluvial drifts, which would cover the primary outcrops of rocks, suggests that these gases are issuing directly from the granite massive, the more that the higher content of rare gases (20 times higher than in the air) excludes every possibility of their being formed at the expense of underground air streams.

Judging by the higher content of radioactive minerals in the rocks, it may be supposed that the accumulation of light rare gases proceeded during many centuries and that these gases are carried out to the surface by the water of springs issuing into the Niman Corridor. Such an assumption is the more probable, since according to W. I. Vernadsky ([1]) gases not combined with water are not to be found in nature.

The gas streams, ascending to the earth's surface, find an outlet at the bed of the river, i. e. in the lowermost portion of the relief, where the upper boundary of the frozen ground is lowered under the influence of flowing waters and at the bed of the river it, probably, disappears altogether.

The gas issues are confined to the joints in granites and centered towards the margins of the granite massive, i. e. to the most fractured zones of the intrusive body. Considering the geological structure of the region under description, it may be supposed that the places, where the gases issue to the surface, are marking points of those planes of disturbance in the granite massive, along which the epeirogenetic movements proceed at the present time.

The close relation between the issues of gas springs and the tectonics of Transbaikalia is shown by Tolstikhin([2]). We suppose that a similar close connexion exists also in the region under description.

Special radiometric work organized in the Niman Corridor would doubtlessly extend our knowledge of this interesting region.

Department of Engineering Geology.
Hydroenergoproject.

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MINERALOGY

EXPERIMENTAL INVESTIGATION OF THE EFFECT OF ALUMINA ON THE OPTICAL PROPERTIES OF TREMOLITE

By D. P. GRIGORIEV

(Communicated by F. J. Loewinson-Lessing, Member of the Academy, 3. II. 1939)

The dependence of the optical properties of minerals of the amphibole group on their chemical composition has not been as yet ascertained with sufficient accuracy. The cause of this is the complex composition of the native amphiboles, owing to which their optical properties are found to be dependent on a number of variables (1).

Since in nature there are no such amphiboles, in which the effect of variables would be pronounced individually, an accurate determination of the above dependence should be regarded infeasible with native material. As a suitable material for the investigation of optico-chemical regularities may serve only artificial amphiboles, whose composition may be set in accordance with the purpose of the experiments.

Up to recently the production of artificial amphiboles has been considered as being very difficult. Only for some time past considerable success has been achieved in solving this problem; the author succeeded in synthesizing amphiboles from silicate melts by the simplest method(2–5).

For the purpose of the present investigation specimens of fluore-tremolite with a different alumina content have been synthesized. As starting material served CaF_2, MgO and SiO_2, taken in proportions equal to those in tremolite, and different amounts of Al_2O_3. Compounds of the above substances ($\sim$20 g) were thoroughly mixed and melted in a cryptol furnace in carbon crucibles at about 1400°; cooling was accomplished in the same furnace in 3—4 hours.

In this way have been obtained tremolite melts with additions of 1,3,5

Table 1

	Melts			
	1	2	3	4
CaF_2, %	18.5	18.1	17.8	16.9
MgO, %	23.8	23.7	22.8	21.8
Al_2O_3, %	1.0	2.9	4.8	9.1
SiO_2, %	56.7	55.3	54.6	52.2
Σ	100.0	100.0	100.0	100.0

and 10% of Al_2O_3 by weight*. The range of the Al_2O_3 content was determined from the fact that the compound without Al_2O_3 produced a non-monomineral melt, and in preparations with a greater amount of alumina the formation of amphibole did not take place. A recalculation of the compounds with the above additions of alumina resulted in the following CaF_2, MgO, Al_2O_3 and SiO_2 contents in the melts obtained (Table 1).

The melts have not been chemically analyzed, since the starting substances were not volatile. Fluorine was the only that might have given a volatile substance in the course of reactions (e. g. with SiO_2) ([6,7]), but duplicate analyses of the melts for fluorine showed its content to approach the one calculated (e. g. in melt № 1 the calculated amount of fluorine is about 9%, and according to the analysis made by E. N. Egorova—9.03%).

Under the microscope segregations of a sole mineral, the amphibole, have been observed in the melts. The amphibole forms long prismatic to acicular crystals without terminal faces (up to 2 mm in length). In some cases the crystals are assembled to radially crystalline aggregates. In cross-sections of the amphibole the prism faces are clearly seen; the cleavage along (110) peculiar to the amphiboles is clearly pronounced; the mineral is colourless and transparent. It is identified as tremolite.

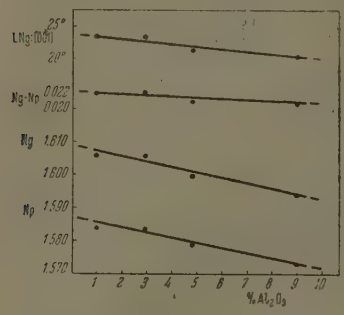

Fig. 1.

Thus, it was found that all the alumina were «assimilated» by artificial amphiboles. For the determination of the method by which Al_2O_3 enters the crystalline structures of amphiboles, the material of the experiments described proved insufficient. For purposes of the present investigation the established fact of Al_2O_3 entering into the amphiboles is sufficient.

In the thin-sections of the melts obtained have been determined both angle of extinction of the amphibole and orientation of the optical indicatrix. The indices of refraction have been measured by means of immersion media, and from these has been calculated the birefringence value. The measurement of other constants proved difficult. All the measurements were made by G. M. Pertel.

The optical orientation of all the amphiboles was found to be similar: N_p =[100], N_m=[010], N_g is lying in the obtuse angle of crystallographic axes.

The results of measurements of other optical properties of artificial amphiboles are summarized in Table 2.

Table 2

Melts	N_g	N_p	N_g—N_p	Angle of extinction N_g : [001]
1	1.606	1.584	0.022	23.5°
2	1.606	1.584	0.022	23.5°
3	1.600	1.579	0.021	21.5°
4	1.594	1.573	0.021	20.5°

* The melts were prepared by V. V. Gurezkaya.

According to the data of Table 2, a graph of the dependence of the optical properties of artificial tremolites on the Al_2O_3 content (Fig. 1) was plotted.

These data show the following changes in the optical properties of amphiboles after the entering of alumina into them: 1) refractive indices decrease, 2) birefringence also decreases though very slightly, 3) angle of extinction (the N_g angle with [001]) slightly decreases.

Similar regularities are already known for natural tremolites, they are fully confirmed by experimental data. When comparing the optical properties of natural and artificial tremolites, it is to be considered that the former are chiefly hydroxyl (but sometimes contain fluorine in quantities up to 2.32%), while the latter are always purely fluoride. Fluorine as such reduces the refractive index values of amphiboles.

The regularities found in the optical properties of artificial tremolites, which confirm the results of investigations of natural minerals, are very important for mineralogy and petrology. After the investigations by Bowen and Schairer ([8]) of rare rhombic amphiboles, these are the first chemico-crystallo-optical regularities experimentally studied in pure synthetical amphiboles. Only a further development of these studies will permit of detailed interpretation of the optical properties of natural amphiboles as dependent on their complicated chemical composition.

Laboratory of Experimental Mineralogy and Petrology.
Mining Institute. Leningrad.

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MINERALOGY

CRYSTALLO-OPTICAL ANALYSIS OF STRONTIUM ALUMINATES

By N. A. TOROPOW

(Communicated by F. J. Loewinson-Lessing, Member of the Academy, 10. II. 1939)

In the course of his systematical investigations of alkaline earths (1) and alkaline aluminates (2), the author studied the optical properties of strontium aluminates. The results of the author's investigation of barium aluminates (1) published in 1935, made by the crystallo-optical method, have been fully confirmed by the X-ray analysis of the $BaO—Al_2O_3$ system, made by S. Wallmark and A. Westgren (3). In particular, the existence has been confirmed of the $BaO.6Al_2O_3$-phase structurally compared to the β-Al_2O_3, which has been corroborated also by the X-ray analysis made by the Scandinavian investigators.

In the course of the present investigation the author was allowed to become acquainted with the X-ray investigation of the $SrO—Al_2O_3$ system, made by K. Lagerqvist, S. Wallmark and A. Westgren (4), who found both the composition and the number of phases identical.

In the paper by K. Lagerqvist and others (4) the formation of four aluminates having individual X-ray diagrams has been established in the $SrO—Al_2O_3$ system. The following formulae are ascribed to aluminates: $3[SrO.Al_2O_3$, $SrO.Al_3O_3$, $SrO.2Al_2O_3$, $3SrO.16Al_2O_3$.

The $3SrO.Al_2O_3$ aluminate is described as a structural analogue of $3CaO.Al_2O_3$ which is confirmed also by W. Büssem (6). Owing to the low symmetry of the lattice and the absence of monocrystals, the structure of strontium monoaluminate failed to be determined more accurately. To the following, third aluminate the formula $SrO.2Al_2O_3$ is ascribed by analogy with a corresponding calcium aluminate, according to B. Tavasci (7) and Beliankin and Shumilo (8); this is a compound of the composition 1 : 2 and not 3 : 5, as has been previously assumed by Rankin and others (9); $SrO.2Al_2O_3$ is also found to be a structural analogue of the aluminate $CaO.2Al_2O_3$.

To the aluminate richest in alumina, whose structure is found to be analogous to the structure β-Al_2O_3, which has been shown for the barium compound as early as in 1935 (1), Lagerqvist, Wallmark and Westgren (4) ascribe the formula $3SrO.16Al_2O_3$ by analogy with the composition of the natural mineral magnetoplumbite $3PbO.16Fe_2O_3$, described by Aminov (10). The synthesis of strontium aluminates has been accomplished by the author after a method previously used for the study of barium aluminates. Due weighed portions of a compound of strontium carbonate and alumina have been pressed to thin cylinders, 0.5 cm in diameter, and fused in the flame of oxy-hydrogen gas. The fused material was crushed, pressed and fused again.

The alloys of strontium oxide and alumina prepared in this way have been subjected to a microscopical examination. The characteristics of the crystalline phases of the system are given below: $3SrO.Al_2O_3$, tri-strontium aluminate, is isolated from the melts in the form of perfectly crystallized trapezohedrons of the cubic system. Optically isotropic. Perfect cleavage, refractive index $N = 1.728 \pm 0.003$.

The $5CaO.3Al_2O_3$ compounds [or $12CaO.7Al_2O_3$ ([11])], analogous to aluminate, have not been detected in the $SrO \cdot Al_2O_3$ system. Alloys intermediate between $3SrO.Al_2O_3$ and $SrO.Al_2O_3$ always seemed to be composed of crystals of both compounds.

$SrO.Al_2O_3$ as strontium monoaluminate microscopically closely approaches the corresponding calcium aluminate. Prismatic crystals with a perfect cleavage in one direction. Pseudohexagonal twinning is frequently observed; reacts with water, $N_g = 1.663 \pm 0.002$, $N_p = 1.649 \pm 0.002$, $N_g - N_p = 0.014$; birefringence considerably lower than with $CaO \cdot Al_2O_3$, this being the chief optical difference between the two minerals.

$SrO.2Al_2O_3$, a strontium dialuminate, microscopically approaches the aluminate $CaO.2Al_2O_3$. Prismatic and acicular crystals. Light refraction $N_g = 1.640 \pm 0.003$, $N_p = 1.614 \pm 0.003$, $N_g - N_p = 0.026$. Angles of extinction up to 45°. Large angle of optical axes. Optical sign positive.

$SrO.6Al_2O_3$, strontium hexaaluminate, an analogue of $BaO.6Al_2O_3$ and other aluminates of the «β-alumina» type. Uniaxial, optically negative crystals with a perfect cleavage along the basis. Light refraction $N_0 = 1.702 \pm 0.003$ and $N_e = 1.694 \pm 0.002$, which coincides accurately with the constants of a corresponding barium analogue.

In a paper by Adelsköld ([5]), who has studied in detail the structure of magnet-plumbite, the latter is also given the formula $PbO.6Ee_2O_3$, analogous to that ascribed by us to barium and strontium «β-alumina».

Laboratory of Silicates.
Institute for Chemical Technology.
Leningrad.

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PHYSIOLOGY

STUDIES ON CENTRAL NERVOUS ACTIVITY

By I. BERITASHVILI, Member of the Academy

There exist several forms of central nervous activity: the innate reflectory activity of the spinal cord and medulla, the individually acquired or conditional reflectory activity of the cerebrum, reproducing the picture of the outside world, the psycho-nervous activity of the cerebrum in animals and the conscious psycho-nervous activity of the cerebrum in man.

The first and second forms of central activity are being studied in many physiological institutes and laboratories of the USSR, the fourth—in the psychological laboratories. As to the psycho-nervous activity of animals, it forms the subject of study—mainly and first—of the Institute for the Study of Animal Behaviour, belonging to the system of the Georgian Branch of the Academy of Sciences, and, besides this, of the Physiological Institute and the Chair of Physiology of the Stalin State University, Tbilissi.

The establishing of the existence of a form of psycho-nervous activity in animals is a completely new achievement of biological research in the field of animal behaviour. It is not as yet widely known. Not even every specialist in the field of animal behaviour research is well acquainted with it. Therefore I intend to devote the present article exclusively to this form of nervous activity, to give a brief account of the results already obtained, trace the paths of its further investigation, and show the practical and theoretical importance of this branch of scientific research.

Both the Institute for the Study of Animal Behaviour and the Physiological Institute are the outgrowth of the First Five-Year Plan. They were created in 1933 on the base of the developed socialist construction of the first five-year period. The work of these institutes developed in the course of the second five-year period. Therefore, it can be said that the theory of the psycho-nervous activity of animals, which is summarized in the following and forms the main part of the science of animal behaviour, has been built up as a whole in the course of the second five-year period.

Our chief task consisted originally in establishing the science of behaviour itself. It is well known that the school of I. P. Pavlov represents behaviour acts as complicated chain reflexes and assumes that acts of individual behaviour are governed by the same laws of nervous activity as conditioned, or, according to our terminology, as individually acquired reflexes. Until 1927 we adhered to the same opinion. However, when we began to study the actual behaviour acts, we arrived at conclusions of a different character. We found that behaviour is a phenomenon of a higher order than the reflex and that it includes reflexes of various kinds as its

elements. We began to give the name of behaviour to such an integral response of the organism which is directed, on the one hand, towards the adaptation of the organism to its surroundings, and on the other, towards such an alteration of these surroundings, thanks to which they become adapted to the needs of the organism.

Under the term reflex, on the other hand, we understand such an external response of one organ or a system of organs, which is executed through the central nervous system in answer to some external or internal stimulus, the aim of the reflex being to co-ordinate the motions of one organ or a system of organs, owing to which the activity of one organ is adapted to that of others, or the stimulated organ is adapted to the stimulus acting on it. If, for instance, we pinch the leg of a cat or a frog, the first that will occur will be the bending of this leg. This will be a bending reflex, with the aid of which the leg withdraws itself from stimulation. But, as a rule, immediately after this, or even simultaneously with it, the animal gets up on its legs and runs away, with its leg bent. In running away the animal makes various circuitous movements, varying according to the surroundings, in which it is obliged to run away from the stimulus. If we attempt to analyze the series of movements made by the animal, it is easy to see that every elementary movement is executed along the type of the reflex: signal—response. But taken in their totality all these movements have a definite aim and direction; the animal does not merely run, it runs away, it runs from its enemy, and frequently it finishes its motion by creeping into some sheltered place. It appears that these motions are done for this purpose—to hide from the enemy.

We find that not only the subject of the science of behaviour is essentially different from that of the theory of reflexes, but that their methods of research are also different. We must apply to the study of behaviour such methods, which provide for a free execution of behaviour acts by the animal.

We have studied in the greatest detail individual behaviour, i. e. such behaviour which follows entirely from individual experience. Let us, for instance, take a dog to a certain spot in the yard, or in a room, give it there something to eat or only to sniff at food. After this the dog will visit this spot many times, when hungry or upon some food signal. This behaviour of the animal we call individual and think that it is entirely of psycho-nervous origin. We have studied this behaviour of the dog with the help of the free motion method. In the course of 10 years of work we have firmly established that a dog responds to the food signal by going from its litter to the trough, which is standing in a place it cannot see and at which it has received food but once, due to the arising of a psycho-nervous process which, on the one hand, reproduces the picture of the location of food and of the road leading towards it, projected to the exterior, and on the other, directs the dog's movements along this road towards this food. This individual food response in a dog may be obtained under such conditions after one feeding from a trough.

We find that the psycho-nervous process reproduced under the influence of one of the elements of a usual situation supplements the psycho-nervous process arising directly under the action of the entire situation in question. Behaviour arises as a response to this complicated process. Further we affirm that if it is permissible to say: the outside world, the outside surroundings determine the character of the animal's behaviour, then it is equally permissible to say that the picture of the usual surroundings, which is reproduced in the animal upon the action on it of some element of these surroundings, must also determine the character of its behaviour. In both cases the beha-

viour of the animal is directed by a psycho-nervous process, which is wholly determined by the action of the outside world.

The psycho-nervous activity of the central nervous system differs from reflectory activity, both innate and individually acquired, in so characterictic a manner that, generally speaking, it is quite easy to decide in every isolated case what kind of phenomenon we are dealing with: a psycho-nervous or a reflectory one. We have established in our experiments on dogs the following characteristic features of psycho-nervous activity.

1. Psycho-nervous activity possesses the property of combining the elements of a definite situation into one integral experience, one integral psycho-nervous complex, after one action of this situation.

2. A most easy reproduction of this psycho-nervous complex under the influence of some isolated component of the corresponding outside situation.

3. The dynamic character, or the continuous variability of the psycho-nervous complex under the influence of various external or internal phenomena.

4. The reproducibility of the psycho-nervous complex during many days and weeks, in spite of its continuous variation.

5. Its extreme activeness: it suffices to stimulate one of its components to obtain immediately the reproduction of the entire complex and, consequently, to bring the entire organism into an active condition.

6. The great ease with which temporary links are formed through the psycho-nervous complex; owing to this, the individual response easily becomes automatic.

7. The dependence of motorial activity of the reproduced psycho-nervous complex on its freshness: it is the more active, the fresher it is, the less time has passed since the moment of its initial arising.

8. The dependence of the motorial activeness of the reproduced psycho-nervous complex on the importance of the elements composing it for the life-activity of the animal. Thus, for the dog the psycho-nervous element, projecting meat in the outside surroundings, is more active than the psycho-nervous element of bread etc.

9. The dependence of the motorial activeness of the same complex on distance, i. e. whether the life important object or the road leading to it is projected on the outside surroundings far or near.

10. The dominant significance of psycho-nervous activity in the behaviour of the dog: it subjects to its rule the automatized behaviour acts and the reflectory activity, eliminating them every time they are no more serving the needs of the organism, owing to changed outside conditions.

All these characteristic features of psycho-nervous activity have been established on the ground of manifold data, obtained by us in studying the individual behaviour of dogs.

We have extended our investigations to other species of laboratory animals. There is a long time since we work on frogs, fishes, pigeons and rabbits, studying on them the various types of individual behaviour. But only during recent years have we studied in detail the individual behaviour of higher vertebrates under more or less identical experimental conditions.

For these comparative studies we took hens as representatives of birds, rabbits as representatives of mammals, occupying a relatively low place in the phylogenetic evolution of mammals, and dogs, being on a relatively high level of phylogenetic development. The behaviour of these animals was investigated in identical experimental surroundings.

All the test animals were first taught a definite feeding behaviour. Upon a certain signal they went from their litter to the trough and after eating returned to their litter. If there are no particular conditions, disturbing

this behaviour, every animal performs this behaviour act in exactly the same manner—choosing for going to the trough and for returning back to the litter always the same short road. Consequently, this behaviour must be regarded as automatized, i. e. proceeding according to the reflex principle. In such cases the signal provokes chiefly the initial movement—getting off the litter, while every section of the subsequent movement is determined by the action of the corresponding section of the outside surroundings, in which the animal proceeds on its way. This automatized feeding behaviour we used as the beginning of feeding behaviour in general. But we did not always use this method for studying individual behaviour. Often we simply called the animal, thus permitting it to leave its litter freely.

The comparison of the psycho-nervous activity of hens, rabbits and dogs, as determined on the ground of this study, leads us to the conclusion that qualitatively this activity is quite identical in every of these species. This follows from the fact that in both rabbits and hens the psycho-nervous activity is characterized by the same features which have been established by us in respect of dogs.

But alongside of this, our tests show a definite quantitative difference in the psycho-nervous activity of hens and rabbits, on the one hand, and that of dogs, on the other, namely psycho-nervous activity of dogs stands on a much higher level. 1) In dogs the reproduced psycho-nervous complex of the location of food and of the ways leading to the food shows a great motorial activeness, after these food and ways have been experienced by the animal but once. In hens and rabbits a high motorial activeness is obtained, only after this experience has been repeated several times. 2) In dogs every psycho-nervous process is reproducible in an active form for a longer period of time than in hens or rabbits. 3) The direct action of food through an unsurmountable obstacle, e. g. through a net, produces in hens and rabbits a more active psycho-nervous process of attempting to get at the food through the obstacle than in the dog. In the dog quite soon the reproduced psycho-nervous process of circuitous ways gets the upper hand. 4) The reproduced psycho-nervous process of the absence of food plays a much weaker active rôle in hens than in rabbits or dogs. 5) The difference in the motorial activeness in respect of different kinds of food maintains in dogs for a longer period than in hens or rabbits. 6) The psycho-nervous activity dominates the acts of individually automatized behaviour in a greater measure in dogs than in hens or rabbits.

On the ground of these observations the conclusion seems justified that in respect of psycho-nervous activity the phylogenetic evolution of the rabbit has not progressed far beyond that of birds. On the other hand, the psycho-nervous activity of dogs stands on a much higher level than that of these two animal species. In this case there is a doubtless progress in comparison with the lower representative of the mammals—the rabbit.

In the first years of the new five-year period we intend to continue our investigation of animal behaviour in two main directions: to arrange a series of comparative studies of the individual behaviour of animals, first of all of lower birds, using those of them which are available for us at the Tbilissi Zoological Garden, for comparing them with the already studied higher representatives of birds, hens and pigeons; in the second place, lower mammals (marsupials), also available at the Tbilissi Zoological Garden, for comparing them with the already studied rabbits and dogs; in the third place, lizards as representatives of reptiles, for comparison with birds; and finally, monkeys, the highest mammal animals (on monkeys of the Sukhumi monkey breeding institution). These comparative studies will supply us with the possibility to follow step-by-step the phylogenetic development

of psycho-nervous activity of animals up to man. We hope to establish the precise form of psycho-nervous activity, the chief biological base, which our animal ancestor must have had at his disposal previous to his humanization with the help of the instruments of labour invented by him.

The other direction, in which we intend to study behaviour, will consist in the investigations of the ontogenetic study of the evolution of behaviour in connexion with structural development. We have chosen hens as the test object for this study. We have begun with the study of the development of the brain. We have already studied the embryonal development of the architectonics of the brain. This will be followed by the study of the conducting tracts and of the neuropyle of the brain, both during the embryonal and the post-embryonal (i. e. after hatching) periods. Parallel with this, we shall study the ontogenetic development of behaviour during the embryonal and post-embryonal periods. This must permit us to follow step-by-step ontogenetically the mutual relations between function and structure. The possibility will be created to determine the main stages of their ontogenetic evolution and to establish the regularities, according to which function is determined by structure and structure by function.

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IMMUNOLOGY

EXPERIMENTAL AND CLINICAL DATA CONCERNING THE CYTOTOXIC STIMULATION OF THE FUNCTIONS OF THE CONNECTIVE TISSUE PHYSIOLOGICAL SYSTEM

By A. A. BOGOMOLETZ, Member of the Academy[1]

In the course of the last few years we succeeded together with our collaborators to demonstrate that by immunizing animals with cellular elements of the spleen and marrow it is possible to obtain sera, which are cytotoxic for the cellular elements of the connective tissue physiological system; large doses of these sera are able to paralyze the functions of this system, while small doses, on the opposite, exert a marked stimulating influence on it. The methods of obtaining anti-reticular cytotoxic for connective tissue sera, and those of determining the content of cytotoxin in the serum of the immunized animal have been described in my previous papers and those of my collaborators.

We refer the reader to the same reports for a detailed discussion of the new notion of the «physiological system of connective tissue», which we have introduced into modern physiology as an extension of the notion of active mesenchyma, as that internal medium of the organism, on the condition of which depends to a considerable degree the normal nutrition of the organism, the condition of its responsiveness and its ability to withstand various morbific influences. This communication will therefore be confined to a brief description of those essentially new results of our work, which seem to me to possess an important practical value.

Proceeding from the conception that the cellular elements of active mesenchyma are the very site where the substances. with the aid of which the organism fights the development of infection within it, are formed, my co-workers Varshamov and Leontiev made upon my suggestion an attempt at intensifying the production of these protective substances by the organism by means of stimulating the physiological system of the connective tissue with small doses of anti-reticular cytotoxic serum. Their experiments were crowned with complete success.

It was found that with the help of cytotoxic stimulation it is possible in many cases to raise the content of protective substances in the blood tenfold. Proceeding from these results, my collaborator Neumann has shown that with insignificant doses of cytotoxic serum it is possible to protect a mouse from infection by an otherwise lethal dose of spirochete Dutton.

Recently I and my co-worker Dr. Marchuk have applied anti-reticular cytotoxic (for man) serum in the clinic of Prof. Ziukov to the treatment of scarlet fever. We found that in many cases the administration of a stimulating dose of anti-reticular serum (0.1—0.3 cm^3) leads in the course of the

next 24 hours to the sinking of the patient's temperature, to a general amelioration of his condition, and the patient enters resolutely the path of convalescence. It is already many years since I put forward the assumption that cancer is unable to reach clinical development in an organism, the physiological system of whose connective tissue has preserved its normal resistance.

Having at aur disposal a means for the stimulation of the responsiveness of connective tissue in the shape of anti-reticular cytotoxic serum, we (in collaboration with Dr. Neumann) applied stimulating doses of anti-reticular cytotoxic (for mice) serum to the prophylactics of cancer in mice. We found that the administration of insignificant doses of our serum produced a marked decrease in the percentage of positive cancer transplantations in the mice, the physiological system of the connective tissue of which has been thus preliminarily stimulated by our serum.

Dr. Neumann, moreover, has demonstrated that with the help of stimulating doses of anti-reticular cytotoxic serum it is possible to achieve in many cases the resorption of large carcinomatous tumours in mice with transplanted cancer. Under usual conditions, tumours which have reached such dimensions are never resorbed and within a short time lead the animal to its death. It proved equally possible to diminish considerably the number of metastases of carcinomatous tumours in mice treated with stimulating doses of anti-reticular cytotoxic (for mouse connective tissue) serum.

These experiments were later continued in my Institute by Prof. Kavetzky, Dr. Fediushin, Dr. Spassokukotzky, Dr. Danerman and Dr. Diadiusha who obtained most interesting results in human carcinomatous patients.

Summarized briefly, these results can be presented in the following main theses. As a rule, the serum of carcinoma patients loses the ability of normal blood serum to lyse carcinoma cells. With the aid of anti-reticular cytotoxic (for man) serum, administered in stimulating dosage (about 0.1 cm^3), it is possible to restore in an overwhelming majority of carcinoma patients the cancerolytic property of their serum.

A most interesting effect is exerted by the cytotoxic stimulation of the mesenchyma of carcinoma patients on the state of their tumours. In many cases it proved possible to observe the disappearance of metastatically affected lymphatic glands, e. g. in cases of cancer of the lip. In some cases it proved possible to obtain, e. g. in advanced forms of carcinoma of the larynx, considerable, though but temporary, improvement. The tumour in a considerable part suffered resorption, the ulcera were healed.

It is important to note the clear analgetic effect of cytotoxic stimulation of the connective tissue in carcinoma patients. We are inclined to explain this effect by the mollification of the tumour as the result of the destructive activity of macrophages, which appear after cytotoxic stimulation, on the tumour elements. Thanks to this, the pressure exercized by the tumour on the sensitive nervous elements is diminished, and the excruciating pain, which one so frequently fails to eliminate by any other means, disappears.

These results, of course, are far from solving the problem of the treatment of clinically developed cancer. As before, cancer must be the earliest possible eliminated by the surgeon's knife, but it seems justified to affirm with assurance that cytotoxic stimulation of the physiological system of connective tissue in carcinoma patients, the chief mass of whose tumours has been eliminated by the surgeon, in many cases will protect the patients from a return of cancer, which so frequently annuls the results of surgical interference.

In view of the enormous prevalence of cancer, we hope that an extensive use of anti-reticular cytotoxic serum as a means of prevention of cancer recidives may preserve a total of numerous years of human life.

It is well known that the healing of fractures involves a high activity

on the part of the cellular elements of the physiological system of connective tissue. In my laboratory Dr. Oleg Bogomoletz studied the question concerning the influence of stimulating doses of anti-reticular cytotoxic (for the rabbit) serum on the rate of the knitting after experimental bone fractures in rabbits. He found that the knitting of bone fractures and the formation of a solid osseous callosity under the influence of cytotoxic stimulation is accomplished in about half the time, necessary for the knitting of the fractures without cytotoxic serum treatment.

These experimental results induced Dr. O. Bogomoletz to transfer his experiments to the traumatological clinic. Anti-reticular cytotoxic serum was found to exert on human bone fractures as well a most active influence, considerably speeding up the process of knitting and the consolidation of the bone callosity. In a number of cases it was possible to achieve the knitting of bone fractures with the help of cytotoxic stimulation, when every other treatment during months remained without result.

Positive results in refractory cases of bone fractures were obtained both in young persons and in aged ones. These data show that in cytotoxic stimulation of active mesenchyma we acquire a new and most active means for the treatment of bone fractures. It produces speedier knitting and aids in restoring normal health and fitness.

Finally, let us cite one more example of the most interesting effect of stimulating doses of anti-reticular cytotoxic serum. We mean the application of this serum in stimulating dosage to the treatment of certain forms of schizophreny.

Anti-reticular cytotoxic serum in doses of about 0.1 cm^3 was applied to the treatment of schizophreny in the clinics of Prof. Frumkin (Kiev) and Prof. Ghiliarovsky (Moscow). We proceeded in this case from indications that active mesenchyma in patients, suffering from certain forms of schizophreny, is functionally defective; on the other hand, active mesenchyma plays an enormous trophic rôle in regard to every kind of cells, nervous ones included.

It was found that under the influence of treatment with anti-reticular cytotoxic serum patients, suffering from grave forms of schizophreny, showed stable remissions, which in many cases permitted the return of these patients to their home surroundings. In a number of cases they were again able to work. The results of these experiments in the treatment of schizophreny with anti-reticular cytotoxic serum were reported at the recent Psychiatric Congress.

It may amaze the reader that one preparation—anti-reticular cytotoxic serum—is so polyvalent, so multifold in the effect produced by it. But it is not the serum that is polyvalent. Anti-reticular cytotoxic serum possesses but one ability: to stimulate, being administered in small doses, the activity of the cellular elements of the connective tissue physiological system, and in large doses to provoke an opposite effect, i. e. to depress their life activity, to block them. It is not the action of the serum that is multifold. Multifold are the functions of active mesenchyma, the functions of the cellular elements of the connective tissue physiological system. Therefore, in ending this communication, we permit ourselves to express the hope that treatment with anti-reticular cytotoxic serum, proposed by us, will become a new therapeutic method which, after having justified its application in a number of cases cited above, will prove useful for clinical medicine in every case, where the cause of the disease or of its delayed disappearance lies in a diminished activity of the physiological system of connective tissue.

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GENETICS

PRODUCTION OF AN AMPHIDIPLOID BASIL *OCIMUM CANUM* SIMS. × *OCIMUM GRATISSIMUM* L. BY COLCHICINE TREATMENT

By V. K. LAPIN

(Communicated by N. I. Vavilov, Member of the Academy, 17. II. 1939)

In connexion with the recent experiments by Blakeslee (1) which opened a new way for duplication of the chromosome complement with the aid of colchicine, analogous experiments on basil were performed by us in the spring of 1938.

As an object was used the F_1 from the cross *Ocimum canum* Sims. × *Ocimum gratissimum* L.

The hybrids between the above named species of *Ocimum* were obtained in 1932 at the Nikitsky Botanical Garden by P. A. Nesterenko (2). The producer later on has kindly put several clones of the hybrids obtained at the disposal of the All-Union Introduction Nursery, where we could conduct the experiments.

As material we made use of cuttings of clone No 30, the oil of which contained over 20% eugenol.

The hybrid F_1 *O. canum* × *O. gratissimum* appeared to be practically sterile, owing to which fact it could be propagated only by cuttings. Single fruits which occasionally developed on the plants usually proved to be incapable of germination.

The need in vegetative propagation of this eugenol-bearing form of basil made the growing technique more complicated and prevented its introduction to northern localities, since this thermophile plant under our conditions can be cultivated only like *Pelargonium*, i. e. as an annual. However, annual culture without seed propagation makes it necessary to keep in heated greenhouses during winter large quantities of stock-plants as a source of spring-cuttings.

The basic object of our experiments was, therefore, restitution of fertility in this hybrid, its sterility depending in our opinion upon incompatibility of its genoms (3).

Apical buds of rooted cuttings which had developed from 4 to 5 pairs of leaves were subjected to colchicine treatment. During 5—10 days aqueous colchicine solution of various concentrations (from 0.125 to 0.5%) was applied to the growing cone with the aid of a dropper. This operation was repeated 3 times daily.

The plants treated in this manner showed at the beginning a slight inhibition of growth as compared to the control ones. The first newly deve-

loped leaves displayed clear signs of malformation, which could not be noticed on leaves developed later.

After the colchicine treated buds had developed into new shoots, the upper parts of the latter were cut and, upon rooting in separate pots, were planted in the open.

Among 24 experimental plants of the clone No 30 grown in this manner, one plant treated with 0.5% colchicine solution gave in autumn abundant crop of fruits, while all the rest, the controls included, bore solitary, occasional fruits.

This phenomenon made one feel sure that doubling of the chromosome number was attained in the hybrid basil by colchicine treatment. However, anatomical and caryological investigations of the fertile plant were undertaken for the sake of greater security.

Stomata, oil-glandules and pollen grains were studied. For the study of stomata epidermis from the lower surface of the middle of the leaf was used; it was taken from the immediate vicinity of the medium nerve. Leaves were taken for this purpose from the corresponding nodes and were kept under similar conditions of illumination during the whole period of growth. Measurements of the length and width of the stomata in the fertile and control plants failed to establish any statistically significant difference (Table 1).

Fig. 1. *Ocimum canum*×*Ocimum gratissimum*. Left—diploid inflorescence dried up without fruit setting; right—amphidiploid plant with fruits normally developed.

No significant difference could either be detected by measurements of the oil-glandules, which are located in depressions on the lower surface of the leaves and represent rather large four-celled formations (Table 2).

Table 1

Sizes of the Stomata in *O. canum* × *O. gratissimum* (in microns)

Plant		n	$M \pm m$	σ
O. canum × *O. gratissimum* (control)	Length	30	32.674±0.367	±2.010
	Width	30	19.586±0.240	±1.318
O. canum × *O. gratissimum* (fertile form)	Length	30	31.894±0.346	±1.795
	Width	30	20.020±0.282	±1.574

Significance of the difference:

Length

$$P = \frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}} = \frac{0.780}{0.493} = 1.582;$$

Width

$$P_1 = \frac{M_2 - M_1}{\sqrt{m_2^2 + m_1^2}} = \frac{0.434}{0.372} = 1.167.$$

Table 2

Sizes of the Oil-Glandules in *O. canum* × *O. gratissimum* (in microns)

Plant	*n*	$M \pm m$	σ
O. canum × *O. gratissimum* (control)	30	83.372±0.725	±3.973
O. canum × *O. gratissimum* (fertile form)	30	83.548±0.071	±0.391

Significance of the difference:

$$P = \frac{M_2 - M_1}{\sqrt{m_2^2 + m_1^2}} = \frac{0.176}{0.729} = 0.241.$$

Quite different results were obtained from measurements of pollen grains which were collected together with anthers and preserved in 5% formalin. The anthers of the fertile form of basil contained considerably more pollen which was, besides, larger than in control (Table 3).

Table 3

Size of Pollen Grains in *O. canum* × *O. gratissimum* (in microns)

Plant	*n*	$M \pm m$	σ	Increase in the size of the pollen grains in %
O. canum × *O. gratissimum* (control) . .	100	50.310±0.483	±4.828	—
O. canum × *O. gratissimum* (fertile form) .	100	73.268±0.762	±7.618	45.63

Significance of the difference:

$$P = \frac{M_2 - M_1}{\sqrt{m_2^2 + m_1^2}} = \frac{22.958}{0.902} = 25.452.$$

The striking increase in size of the pollen grains in the fertile form *O. canum* × *O. gratissimum* which attained 45.63% supported our supposition on the doubling of the chromosome number, which was completely proved by subsequent caryological study of the meristematic root-tips fixed in chromic acid, acetic acid and formalin.

Referring to data obtained from measurements of stomata and oil-glandules, the lack of any increase parallel to chromosome doubling in *O. canum* × *O. gratissimum* should be emphasized. This fact should warn experimenters from using the size of stomata and of oil-glandules for the preliminary selection of the polyploid plants.

Although there are numerous literary data demonstrating increase in size of the stomata in polyploids (3), we find it possible to apply this criterion only when such a relation is established in each species individually. Obviously free cells, such as are the pollen grains, would be a more reliable index.

The amphidiploid form of *O. canum* × *O. gratissimum* experimentally produced by us, aside from its ability of setting fruits, was distinguished by somewhat larger flowers and fruits. The lamella of the leaf was somewhat broader and had larger indentations along the edge. Flowers were unevenly arranged along the axis of the inflorescence and formed two-story whorl which consisted of two closely adjoining half-umbels. In the diploid form the half-umbel were set apart at equal distances.

At the end of flowering period the difference between the diploid and amphidiploid forms of *O. canum* × *O. gratissimum* became especially striking,

as the flowers shrinked withoud fruit setting in the former, while in the amphidiploid the whole flowering part was turned into a group of fruits, the calyx preserving its original dimensions and containing fruit (figure).

The counts of fruits in the diploid and amphidiploid forms has shown that while in the latter the mean number was 2 fruits per calyx, in the diploid the corresponding number was only 0.08 (Table 4).

Table 4

Number of fruits

Plant	Number of fruits counted	Total number of fruits	Mean number of fruits per calyx	Calyces containing				Empty calyces
				4 fruits	3 fruits	2 fruits	1 fruit	
O. canum × *O. gratissimum*, diploid	200	15	0.08	—	—	—	15	185
O. canum × *O. gratissimum*, amphidiploid	200	400	2.0	52	11	52	55	30

The crop collected from the amphidiploid plant consisted of over 3000 fruits; tests have shown them to be capable of germination. Taking into account that the amphidiploid plant had suffered a certain depression under the influence of colchicine, still greater yield should be expected in the next generation, which opens a possibility of propagating the eugenol-bearing hybrid basil by fruits instead of cuttings.

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PLANT PHYSIOLOGY

CHANGES IN THE CONTENT OF GROWTH SUBSTANCES DUE TO INTERRUPTION OF THE PERIOD OF REST

By L. M. JARKOVAJA

(Communicated by A. N. Bach, Member of the Academy, 28. I. 1939)

The first studies on the change of the growth substances content at the transition stage from rest to growth were made by Zimmerman ([10]), Dagys ([8], [9]) and Avery with his collaborators ([7]). Zimmerman using the Went method has shown that termination of the period of rest was connected with an increase in the content of growth substances of the A-group in buds of *Acer pseudoplatanus* and *Fraxinus excelsior*. Avery, who has similarly used the Went method, has found that sprouting of dormant buds in *Aesculus hippocastanum* L. and in apple-tree was connected with a striking increase in growth substances content. Dagys using the yeast method has shown that natural interruption of dormancy greatly increased the content of the growth substances of the bios-group in buds of *Quercus robur* and *Salix fragilis*.

The purpose of the present work included clearing up the question on the change of the content of growth substances at interruption of the period of rest by means of warm baths and wounding in tubers of potato and in buds of lilac and trifoliate orange. Determination of the growth substances of the B-group was made by the yeast method following Verner and Kling ([2]). Determination of the growth substances of the A-group was made by method applied by Cholodnyj ([5]) in his experiments on isolation of the growth substances of the seeds of grasses. The method described by Cholodnyj was used in our experiments in a somewhat modified form; the modifications consisted in that coleoptiles were placed in a horizontal position instead of a vertical one.

The drop of gelatine was on the lower side of the coleoptile. As shown by experiments, horizontal position of the coleoptiles increased their sensitivity and made it possible to determine the growth substance obtained from a small amount of plant material. The experiment continued for 2 hours; during this time the control coleoptiles which were placed horizontally showed no bending, while the experimental ones have bent upwards under the influence of the growth substance penetrating from the drop of gelatine. The quantity of the growth substance was expressed in the angle of bending measured in degrees.

As a material for the work were taken tubers of potato (*Solanum tuberosum*), buds of lilac (*Syringa vulgaris*) and trifoliate orange (*Poncirus trifoliata* Raf.).

Experiments with Tubers of Potato (1937). As a simplest method for intercepting the period of rest in newly harvested tubers of potato was applied removing of the skin. Positive effect of wounding tubers upon sprouting of their eyes was noted in the experiments by Jost and Appleman ([6]). Sprouting of the tubers was similarly observed after skinning. Burachinsky ([1]) succeeded in interrupting rest in great quantities of newly harvested tubers intended for practical summer planting.

Experiments on determination of the growth substances at interrupted rest were conducted with newly harvested tubers of potato, variety «Early Rose». After removing the skin, tubers were placed into boxes with moist sand. Samples for determination of the growth substance content in the control tubers and in the experimental ones were taken at the beginning of sprouting of the eyes of the experimental tubers. Sprouting of the eyes in experimental tubers usually began 10—12 days following skinning, while the control tubers began sprouting after 3 months, in the middle of December.

The growth substances were determined in various parts of the tubers; in the eyes, in the skin with a layer of flesh adjoining to it, in the cambium zone of the central portion of the tuber. Each portion was cut into small pieces and boiled in water during 2 min., 10 cm^3 of water being used to each gram of material. 3 cm^3 of extract was put in a small retort (boiling bottle) containing 25 cm^3 of Hayduk's mixture prepared on ordinary tap water. As a control served small retorts containing Hayduk's mixture, to which 3 cm^3 of water were added. The retorts were then sterilized during 30 min. at a temperature of 110° C. After sterilization 1 cm^3 of yeast suspension was added to each retort; yeast used was grown on Hayduk's medium. Retorts (bottles) inoculated in this manner were placed for 24 hours into the thermostat at a temperature of 30° C. Quantitative determination of yeast was made with the aid of the counting camera of Hellige (Hellige eyepice, object lens No 14).

Experiment 1. The results of the experiment started on September 19 and concluded on September 20, 1937, are given in Table 1; they show that different portions of a tuber contain different amounts of growth substances.

Table 1

Content of the B Growth Substance (experiment of Sept. 29, 1937)

Parts of the tuber	Average number of yeast cells from 10 counts in the field of the counting net of the camera	
	Rest interrupted	Rest uninterrupted
Buds	82	28
Periderm	26	23
The cambial region	126	69
Central portion of the tuber	59	58

Thus, the content of the growth substance B is greater in the cambial region of the resting tubers than in other parts of the tubers. When rest is interrupted artificially, the content of the bios in the cambial zone is increased nearly twice. Moreover, the content of bios in the eyes increases nearly three times. Thus, upon artificial interruption of the period of rest in the tubers of potato variety «Early Rose», the content of bios increases in the cambial zone and in the eyes, while it remains almost unchanged in the central and peripheral portions. The experiment on determination

of the growth substance A in various parts of the tuber of potato Woltmann was conducted on the 7 March, 1938, when the rest of tubers was naturally interrupted after the winter dormancy; it has shown that the content of the growth substance A was different in different parts of the tuber. Maximum amount of growth substances was found in sprouting eyes. Thus, under the influence of the extract prepared from eyes, the coleoptiles of oats showed bending for 28°, while the extract from the periderm caused a bend of 17°, the extract from tissues of the cambial region of 20° and, finally, that from tissues of the central portion produced bending for 8°.

Experiments with Lilac (*Syringa vulgaris*). Experiments with lilac were started after fall of leaves in October, 1937. For the experiments were taken branches 45—50 cm long. The period of rest was interrupted in lilac with the aid of warm baths following Molisch (3). The branches were kept during 12 hours in water heated to 35° C. Then treated and control branches were placed into vials containing water and left in a greenhouse at a temperature of 19—25° C.

In the experiments with lilac were determined the growth substances A and the bios. Samples (weighed portions of buds) were taken at the beginning of sprouting from branches treated with warm bath. Extraction of the growth substances was accomplished by means of boiling buds during 2 min. in water (10 cm^3 of water to 1 g of buds). Determination of the bios was made in the way described above for potato; 2 cm^3 of extract was introduced into the retorts (boiling bottles) containing Hayduk's medium. Experiments were made in two repetitions. For determination of the growth substances A 2 cm^3 of the extract were taken. The samples were evaporated on a water bath, until they reached the volume of 1 cm^3 and 1 cm^3 of 12% gelatine was added to each. Coleoptiles with a drop of 6% gelatine applied to them served as control.

Table 2

Content of Bios in the Buds of Lilac

Sample taken	Buds	Average number of yeast cells, out of 10 counts in the field of the counting net
23.X.1937	After the warm bath .	256
Do	Control	11
11.I.1938	After the warm bath .	300
Do	Control	40

Table 3

Content of the Growth Substance A in the Buds of Lilac

Sample taken	Buds	Angle of bend in degrees
23.X.1937	After the warm bath . .	22
Do	Control	13
11.I.1938	After the warm bath .	26.5
Do	Control	17

The results of determination of the growth substance B are presented in Table 2. From Tables 2 and 3 it follows that an increase of the content of growth substances A and B is connected with artificial interruption of the period of rest.

Experiments with Trifoliate Orange (*Poncirus trifoliata* Raf.) were started in January, 1938. Two years old seedlings of the trifoliate orange grown in pots were taken for the experiment. The period of rest was interrupted by means of a treatment of the overground parts with warm baths at a temperature of 35° C during 12 hours.

The experimental and control individuals remained on the bench of the greenhouse at a temperature of 20—22° C. In treated plants sprouting of buds has begun 2.II, i. e. after 24 days, while in the control after 50 days.

Method of determination of the growth substance was the same as in experiments with lilac. The sole difference consisted in that samples for preparation of the extract were taken not from buds, but from the whole shoot. Samples were taken 36 hours following treatment with warm water.

The results of experiments are presented in Table 4.

Table 4

Content of the Growth Substance B in the Shoots of *Poncirus trifoliata*

Date of the experiment	Shoots	Counts made as in Table 2
8.I.1938	After the warm bath	116
Do	Control	47

It may be seen from Table 4 that content of the bios in shoots of *Poncirus trifoliata* Raf. increases upon artificial interruption of rest.

In conclusion it should be noted that the results of the above experiments on determination of the growth substance upon artificial interruption of rest in tubers of potato, in lilac and trifoliate orange are in favour of the assumption that increase of the content of growth substances B is a regular phenomenon. To draw conclusions on the change of the growth substances A due to artificial interruption of rest further experiments are necessary, however, it may be supposed from the experiments with lilac that the type of change of the substance A as a result of artificial interruption of rest would be the same as in lilac in other plants too.

Comparison of our data with those of Zimmermann and Dagys lead to a conclusion that the character of change of the content of growth substances is the same in the cases of both artificial and natural interruption of rest. In the two cases sprouting of resting buds is correlated with an increase in growth substances.

Timiriazev Institute of Plant Physiology.
Academy of Sciences of the USSR.

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PLANT ANATOMY

SEPARATION OF MEMBRANES OF STARCH GRAINS IN VARIOUS CROPS

By M. I. KNJAGINICHEV

(Communicated by N. I. Vavilov, Member of the Academy, 19. II. 1939)

Great practical importance of starch has long been attracting the attention of those who worked on formation of starch, its structure, properties, etc. A number of anatomical investigations have shown that, by means of a suitable treatment of native starch, small blocks («Blöckchen») may be revealed ([1],[2]), arranged parallel to the surface of the starch grain; it has been demonstrated, moreover, that small and large starch grains are derived from different anatomical elements of the cell at different phases of seed maturity ([3],[4]). It has been, finally, established that small starch grains differ from the large ones in chemical composition and in other properties ([5],[6],[7]).

However, despite such a detailed study of starch and starch grains, it still remained obscure what were the causes responsible for the varying digestibility in starch by diastase (resistance of native starch). It has been established that only in the case of gellification digestibility by diastase of the starch in different crops was practically equal. In the light of the most recent works on the structure of starch [Haworth and collaborators ([8]) and some others ([9])] starch of all the crops should be digested to the same extent inasmuch as it consists of 24—26 glucose radicals.

It was suggested earlier from indirect evidence that the outer layers of the starch grain have a composition differing from that of its inner part. However, no method for separation of the starch grain into its constituents has yet been suggested.

While studying biochemistry of proteins and starchs, we succeeded in finding a solvent ([10]), sodium salicilate, which made it possible, when used in definite concentrations, to isolate the contents of the starch grain, the starch proper, from the surrounding membrane.

The method consists in placing a small quantity of washed starch on an object glass ([6]) and its mixing with two small drops of 30% solution of sodium salicilate. The slide is covered with a cover glass and left for 30—60 min. (depending on the kind of starch), until the membrane bursts and the content of the starch grain is dissolved in the sodium salicilate. It may be seen under the microscope that the starch grains, without swelling noticeably, quickly (from 3 to 30 min.) burst and starch flows out of them. Lack of swelling demonstrates the difference of the nature of the two parts of the starch grain. While the membrane itself is not soluble in this reagent, it lets sodium salicilate pass into the starch grain; the starch, on the other hand, swells upon coming in contact with the solvent and breaks the membrane.

The slide is then repeatedly washed during from 40 to 60 min. with a 30% solution of sodium salicilate in order to remove starch; then it is washed during the same time with water, to remove the solvent, after which the membranes are stained in iodine solution in glycerine plus potassium iodide, diluted with an equal part of water. The membranes become stained here into a reddish-violet or bluish-violet colour. When starch solution in sodium salicilate is not completely washed out from the membranes, the starch is precipitated by iodine solution and becomes intensely stained into a rather light blue colour.

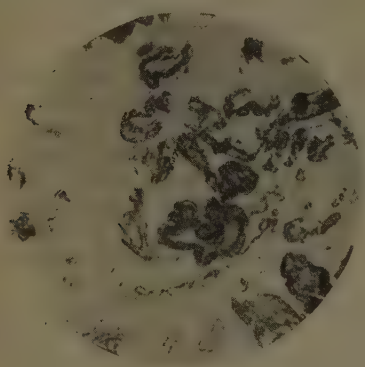

Fig. 1.

Fig. 2.

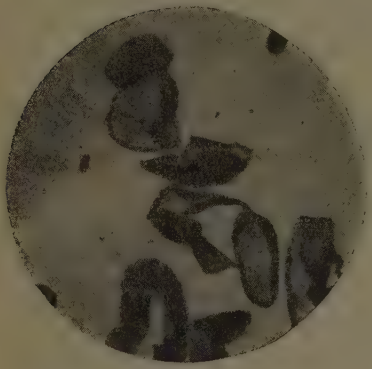

Fig. 3.

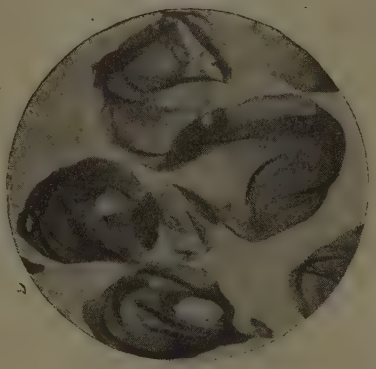

Fig. 4.

Microphotographs of the membranes of the starch grains: 1—wheat (variety *Hordeiforme* 0189); 2—rye Tulunskaja; 3—beans Triumph; 4—potato, *Solanum Rybini* (magnification 80 times).

We have isolated the membranes of the starch grains in wheat, barley, rye, rice, cow-pea *(Vigna sinensis)*, sugar peas, wrinkled-peas and of the rounded peas, beans and potato. Some of them are represented in the microphotos.

With regard to thickness of the membrane starch grains may be subdivided into three groups, viz.: the thinnest membranes are peculiar to wheat (all the species), rye and barley; beans, *Vigna* and round peas possess membranes of medium thickness; the thickest (rough)membranes occur in potato, rice and sugar wrinkled-peas.

Yet, in the light of the data obtained (differences in the thickness of the membrane) the differences observed among starches of different crops with

regard to resistance to diastase remain inexplicable. Striking differences with regard to this character among different crops make one postulate the existence of some unknown membrane-splitting ferment, which is more or less specific for any given plant genus or group of genera. The experiments on hydrolysis of membranes freed of traces of starch in potato, rice and sugar wrinkled-peas have shown, it is true, that membranes were completely hydrolyzed both with glycerine extract of barley malt and by introduction of the dry preparation obtained by falling from 20% alcoholic solutions of malt*.

This ferment is apparently very closely related with regard to certain properties to the amylases studied, since hydrolysis of membranes can hardly be explained by the effect of some of the ferments presently khown, inasmuch as the specifity of their action has been sufficiently well studied.

An argument against the supposed existence of the new ferment consists in the recent data ([11]) on the effect of the electrokinetic potential of the surface of the starch grain on the velocity of hydrolysis. One should assume in this case, then, that the properties of outer surface of the membrane of the starch grain are strikingly different in different crops, while the inner side of the membrane of the starch grain is similar in all of them. This idea is experimentally based, as it has been established that formation of starch begins in the inner cavity of the plastid ([12]).

It is equally true that the nature of the membranes of the starch grain is absolutely dependent on the plastids, which suffered alterations in the evolution of genera and thus caused differences in thickness and in other properties of the membranes of the starch grains.

All these questions may be solved only by further experiments.

At present by an analogous method chemical isolation of the membranes is conducted in order to study chemically both the membranes and the contents of the starch grain.

In concluding it is necessary to make the following statement:

1. The advanced method of isolation of membranes insures the possibility of biochemical and anatomical study of the isolated parts of the starch grain of different crops.

2. On the basis of numerous investigations on the resistance of starch to diastase it is necessary to assume the existence of an unknown ferment which splits the membranes of the starch grain; this ferment should be more or less specific for different genera or groups of genera.

3. Solution of sodium salicilate may be used to work out a new method for quick quantitative determination of starch.

Biochemical Laboratory.
All-Union Institute of Plant Industry.
Leningrad.

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* Digestibility of starch dissolved in sodium salicilate is equal to that of aqueous paste.

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PHYTOPATHOLOGY

ACCUMULATION OF VIRUS OF TOBACCO MOSAIC IN PLANTS WHEN NITROGEN IS WITHHELD FROM THEM

By V. L. RISCHKOV and V. A. SMIRNOVA

(Communicated by V. L. Komarov, Member of the Academy, I. II. 1939)

After the protein nature of the virus of tobacco mosaic had been established, the problem came to the fore as to what is the place of that virus in plant's metabolism. We started with some experiments towards a solution of this complicated problem. The task we set before us was to find out how the formation of the virus proceeds in a diseased plant deprived of nitrogen. A normal plant when growing under such conditions is known to lose part of their proteins. There arises the question whether a diseased plant may on starvation utilize the virus depositing in its cells in the form of Ivanovsky's crystals. If not, will the process of virus accumulation go on as intensively, as it does when the plant is sufficiently supplied with nitrogen?

The experiment was run in three sets with tomatoes. Part of the plants, which all started growing under normal conditions, were infected with the virus of tobacco mosaic, and not until the symptoms of the disease (filiform leaves and mosaic) became sharply expressed, did the experiment begin.

The first set of tests served the purpose of orientation. They involved sound and infected plants in earth, plants in sand, watered with a solution of full nutrient value, and other plants in sand supplied with a solution, in which the nitrate was substituted with $CaCl_2$. The plants of the first set were growing in earthen pots, those of the second and third set—in vegetation vessels. In these latter sets the sound and infected plants were set in sand which was watered either with normal nutrient solution or with that, in which nitrogen was replaced by $CaCl_2$.

The sets varied in the number of days elapsed from planting till infection and from infection till elimination of nitrogen, as shown in Table 1.

Table 1

Set	Days after planting	Days after infection
1	38	29
2	52	32
3	27	16

The first, second and third sets included 159, 32 and 80 plants respectively. In order to prevent their attacking by insects, the plants were enclosed into special boxes and became therefore somewhat etiolated.

In the first set of tests where no strict conditions were secured in cutting off nitrogen (earthen pots), we failed to observe any inhibition of development in the plants supplied by the solution containing no nitrogen. But their chemical analysis showed that in the first set too the amount of proteins in the plants deprived of nitrogen was strongly reduced. In the second and third sets the plants lacking in nitrogen lagged behind in growth and developed less leaflets compared to those grown under normal conditions.

In order to determine the titre of the virus, we took leaves from the infected plants grown with and without nitrogen in the nutrient medium and, after having ground them separately, diluted the juice with $^1/_{10}$ *n* solution of Na_2HPO_4, until 99 or 999 times the volume of the sample had been added. The titre of the virus was estimated from the number of necroses on a leaf of *N. glutinosa*, one half of the leaf being infected with the juice from plants supplied with nitrogen and the other half with the juice from plants lacking in nitrogen. The results were subjected to statistical treatment in two ways. The first way was to follow the usual method of virological investigations, taking as variants the numbers of necroses on one of the leaf halves; the second way consisted in considering the difference between the numbers of necroses on both halfes of the leaf. Accordingly, two indices of statistical significance *(t)* were computed; one for the values obtained by the first method, another for those obtained by subtraction. The reasons in favour of recurring to the second method on calculating the significance of the data obtained from determination of titres have been put forward in a paper by Rischkov and Gromyko [Microbiology, VII, № 8 (1939)].

In such investigations as our account should be taken of the fact that the amount of virus accumulating in different portions of the leaf, let alone in different leaves, is highly variable. The individual variations in different leaves as to the titre of the virus may, possibly, be ascribed erroneously to the different conditions of their nourishment. To reduce the possible error we took the leaves from the respective whorls in the plants supplied with and deprived of nitrogen. Furthermore, the individual differences between the leaves were smoothed out by expressing the juice from several leaflets belonging to different plants. The results are summarized in Table 2.

From Table 2 it may be seen that in none of the cases have the differences in the titre between the experiment and the control given significant data, when calculated according to the usual method. And it is only in one case that they become significant in favour of the control and in one case in favour of the experiment, when calculated from the difference. These data lead us to a conclusion that under conditions of nitrogen deficiency the virus protein is not let by the plant to take part in metabolism and even continues accumulating, its concentration in the juice of a minus-nitrogen plant being not inferior to that in the juice of a plant supplied with nitrogen normally. Since the mass of a plant deprived of nitrogen is below that of a normally nourished plant, the absolute amount of virus in the former should be lower than in the latter.

The relation of the virus protein to the synthesis of plasmatic proteins is well characterized by the fact that the diseased plants suffer much more from the lack of nitrogen than the sound ones. If the plants of the first set showed no external symptoms of nitrogen deficiency and in the second and third sets both the diseased and sound plants of the minus-nitrogen variant were behind of the development of the others, nevertheless, this delayed development due to elimination of nitrogen was by far more sharply expressed in the plants infected. This was especially conspicuous in the experimental plants of the third set, which had been deprived of nitrogen the least number of days after planting and infection and therefore had had less time for storing nitrogen compared to the plants of the first two sets. The data relating to the third set are summarized in Table 3. Here the development of experimental plants is expressed in %, the respective value for sound plants supplied with nitrogen being taken equal to 100.

Two facts may be considered established: 1) the virus continues accumulating in plants suffering nitrogen deficiency; 2) though the infection of plants

Table 2

Titre of Virus of Tobacco Mosaic in Tomatoes Grown with and without Nitrogen

Material	Number of days from the outset of the experiment	Number of leaves	Average number of necroses per leaf half of *N. glutinosa* and average error		Difference in the number of necroses	t_1	t_2
			+ N	— N			
I set	63	19	70.42±8.9	57.73±8.3	12.7±4.69	1.10	4.69
I » *	71	20	3.65±1.03	3.50±0.89	0.15±0.63	0.74	0.24
II » * . . .	42	20	4.80±0.93	3.00±0.84	1.82±0.82	1.44	2.22
II »	77	50	71.30±6.03	74.90±6.19	3.60±2.67	0.416	1.35
II »	80	50	46.70±3.59	48.80±4.024	2.12±1.19	0.389	1.80
III » * . . .	20	20	4.75±1.07	6.55±1.145	1.80±0.94	1.15	1.91
III »	31	20	7.85±1.62	10.90±2.78	3.05±2.78	0.95	1.08
III »	40	20	22.90±2.625	21.35±2.47	1.55±1.55	0.43	1.0
III »	51	46	21.48±1.725	24.15±1.88	2.67±1.17	1.047	2.28

Note. t_1 — calculated directly; t_2 — calculated from the difference.* Dilution 1 : 1000, in the other cases 1 : 100.

Table 3

Development of Diseased and Sound Tomato Plants with and without Nitrogen

Plant	Height by 4.IX.	Number of leaves by 4.IX	Weight by 16.X	Dry weight by 16.X
Sound + N	100.0	100.0	100.0	100.0
Sound — N	79.2	84.2	35.6	34.7
Diseased + N	95.2	98.2	106.6	120.0
Diseased — N	56.5	75.0	6.18	9.0

with the virus fails to retard their development under the condition of our experiment when they are supplied with nitrogen normally, nevertheless on elimination of nitrogen the diseased plants suffer by far more than the sound ones. These two facts must be interpreted to mean that after nitrogen is cut off, the virus is being built up farther at the expense of the «sound» proteins of the plant. The virus protein behaves here as a typical parasite.

The results obtained could by no means have been anticipated. Starving plants are known to utilize the protein crystalline formations which normally occur in their cells. Even the symbiotic bacteria (nodule bacteria) may be turned to account by a vegetable cell under certain conditions. On the basis of the experiments here reported the virus nucleoproteid can be characterized as parasitic protein.

Conclusions: 1. When nitrogen is withheld from tomatoes attacked by tobacco mosaic, the formation of virus is still in progress and the titre of the virus in the juice of starving plants is not lowered compared to plants supplied normally. 2. The diseased plants are much more badly affected by cutting off nitrogen than the sound plants. 3. On the basis of the experiments reported, the virus of tobacco mosaic may be characterized as parasitic protein.

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PHYTOPATHOLOGY

ON PARACRYSTALS OF TOBACCO MOSAIC VIRUS

By N. N. KLEMPARSKAJA

(Communicated by V. L. Komarov, Member of the Academy, 1. II. 1939)

A number of authors have been studying the properties of protein paracrystals of tobacco mosaic virus.

The study embraced physical, chemical, optical properties of the crystals, but their ability to take on different colours has been but scarcely investigated. The question of how protein crystals stain is interesting, however, both from the point of investigation of their structure and from that of comparison with the staining of those elementary bodies, whose presence characterizes the virus diseases of animals.

On the suggestion of Prof. V. L. Rischkov who was formerly dealing with that question, we started working having set ourselves the following tasks:

1. To find adequate methods for fixing and staining the crystals in question.

2. To compare the response of the crystals to various dyestuffs with the staining of the elementary bodies.

3. To study the behaviour of the crystals under the action of a specific serum.

The crystals for the colouring test were taken from a tomato plant attacked by tobacco mosaic, according to the method of Rischkov and Gromyko. The crystals suspended in a semi-saturated solution of ammonium sulphate stain very poorly (gentian-violet imparts them a lightly-violet shade) or will not stain at all (under the action of fuchsin or methylene blue).

The investigation was being performed by blending the drops of crystalline suspension with those of the dyestuff solution on the object glass, and examination done with dry and immersion objectives.

The crystals are much easier to stain when they have suffered the action of some fixing solutions.

A drop of crystalline suspension on the object glass was dried and the preparation either immersed into fixative or the latter was applied by drops. Afterwards the preparation was thouroughly rinsed with distilled water and subjected to the action of the dyestuff. As fixative, we first used saturated alcohol solution of picric acid (during 2—3 min.), recommended by Prof. Rischkov.

Fixed crystals stained well under the action of both basic and acid dyestuffs, e. g. acid and basic fuchsin, gentian-violet, Victoria blue 4R, thionin, haematoxylin and others. The central, middle portion of the crystal stains

more intensely than the fine tips. The distribution of the colour is even, homogeneous. No internal, structural differentiation could be detected.

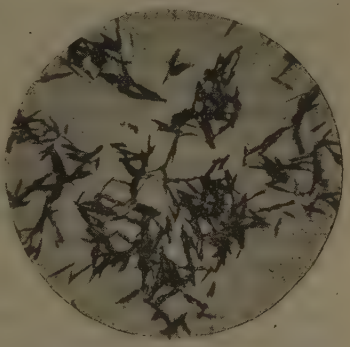
Somewhat less dense and vivid were the colours imparted to the crystals by compound stains. Gimza stain (16 hours) gave them a pale violet shade; Unna stain (16 hours), a pale pinkish-violet one. Pale looked also the colours imparted by safranin, neutral red and methylene blue.

Besides picric acid, the following solutions can be used as fixatives: 1) 96° alcohol with formalin (1, 5, 25, 50%); 2) tannin 0.001—0.01% (stronger solutions are destructive); 3) normal solution of hydrochloric acid.

With these methods of fixation applied the crystals take on colour equally well whether stained by acid or basic dyestuffs. 96° alcohol or 40° formalin will not suffice if applied alone, for the crystals so fixed stain pale.

Trichloroacetic acid (1—10%) and potassium bichromate cannot be used on account of their destructive action upon the crystals.

The crystals are variously arranged on the preparation, according to the concentration of the initial suspension, either forming a continuous net, or lying separately, or being stuck with their ends parallely or at varying angles (figure).



Paracrystals of tobacco mosaic virus stained according to M. A. Morosov (microphotograph taken with immersion objective).

The conclusion to be drawn from these observations is that the protein crystals of tobacco mosaic virus, contrary to the elementary bodies, are readily stainable by all dyestuffs and have no strictly specific relation to any of them.

For the sake of detailed comparison with the elementary bodies the crystalloid preparations were stained after the method of M. A. Morosov. Preparations of vaccinic elementary bodies, kindly supplied by Prof. Morosov, served as controls. The crystals turned pale-yellow or dark-brown, according to the intensity of the colour.

By treating the preparation with distilled water previous to fixation (according to M. A. Morosov), we have obtained the following result: the crystals dissolve and the whole of the field of vision is occupied by small globular formations of no perfectly equal size and varying in colour between brown and black.

Similar minute, point-like formations may be observed in the smears of a dialyzed colloid solution. By their outward appearance these formations sometimes resemble the elementary bodies. This phenomenon will be studied by us in more detail.

Along with the experiments here reported we tested the crystals by treating them with a specific serum. The action of the latter upon the virus of tobacco mosaic was studied mainly on solutions of that virus.

In our experiments the suspension of crystals in a 20% solution of ammonium sulphate was mixed directly (either on the object glass or in a test-tube) with an equal amount of the serum, specific with regard to the virus of tobacco mosaic. The final concentration of ammonium sulphate was thus made to 10%. The effect of the serum (or its dilutions 1 : 5, 1 : 10, 1 : 25) was to produce a rapid agglutination of the crystals, which united into flakes of varying size.

This phenomenon should be ascribed to the specific property of the serum

applied, since it fails to appear when a serum specific to proteins of a sound plant or sera of agglutinant bacteria are added to the suspension of crystals.

The serum endowed with specific action on the virus of tobacco mosaic not only glues the crystals together, but is adsorbed by them and alters their physico-chemical properties. Agglutinated crystals are stable and do not dissolve in distilled water after ammonium sulphate has been removed, say, by means of dialysis.

On dialyzing the mixture of crystalline suspension and specific serum in a collodion bag during 2 or 24 hours, one may detect crystals which have escaped dissolving (directly in unstained condition or in stained preparations). The behaviour of the crystals in response to various dyestuffs is not affected by the action of serum. In control experiments the dialysis of crystals mixed with non-specific sera or of crystalline suspension alone always resulted in complete dissolving.

Aside from specific agglutination of crystals by the corresponding serum one can observe the phenomenon of non-specific agglutination on addition of various substances. Some of the latter—tannin (0.01—1% solutions) and hydrochloric acid (normal solution)—are analogous to the specific serum, inasmuch as their effect is not only to glue the crystals together, but also to make them stable to dissolving in distilled water. We may therefore suppose the analogy between those substances and the specific serum to lie as deep as in the mechanism of their action. When the mixture of crystals with tannin or 1 *N* HCl is dialyzed, the crystals preserve their structure and are readily stainable during 24—48 hours and more.

As to the other substance capable to produce a non-specific agglutination, as tartrates, sulfates and citrates of sodium, and the saturated (70%) solution of ammonium sulfate, they unite the crystals indeed, but as soon as the mixture has been diluted (i. e. the concentration of the substance has dropped) the agglutination is no longer sustained and the crystals dissolve on dialysis. Consequently, no deep changes in the nature of the protein take place here, contrary to what is observed when tannin, hydrochloric acid or the specific serum are acting on the virus of tobacco mosaic.

Conclusions

1. Fixed paracrystals of tobacco mosaic virus are readily stainable with basic and acid dyestuffs and this distinguishes them from the elementary bodies.

2. When the method of M. A. Morosov is applied, the colouring range of the crystals lies between yellow and dark-brown. In the preparations, in which the crystals are held in solution, small globular grains of brown or black colour may be observed.

3. A specific agglutination of crystals may be produced by the action of the respective serum, and a non-specific one, due to various substances.

4. The crystals denatured by the specific serum, tannin or hydrochloric acid are insoluble in distilled water on dialysis.

Laboratory of Vegetable Viruses.
Institute of Microbiology.
Academy of Sciences of the USSR.
Department of Microbiology.
I Medicine Institute.

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EXPERIMENTAL MORPHOLOGY

ON THE RESPIRATION OF LARVAE *LEUCASPIUS DELINEATUS*

By F. I. BEZLER

(Communicated by I. I. Schmalhausen, Member of the Academy, 26. II. 1939)

One of the objects of studying gaseous exchange at various stages of development is to make clear the relation between oxidation and form-building processes.

With reference to the aforesaid problem, quite a large amount of information is available ([1—14]).

In the works enumerated above relatively little attention was paid to gas exchange during the larval stages of development, whereas it is exactly the larval period which is characterized by the appearance and development of respiratory organs. The vascular system is a provisory organ of respiration in larvae. K. Baer ([15]) was the first to suggest it, and during recent years S. G. Kryˇanovsky ([16]).

The present work had for its purpose the study of the general course of changes in respiration in Cyprinid larvae in correlation with the development of larval blood vessels and gills.

Larvae of *Leucaspius delineatus* served as the object of the present work.

The oxygen absorption was determined by means of two stationary Winterstein respirometers modified after Dixon's ([17]) method. As a rule, was tested material separated from the membrane. Into a vial were usually introduced about 30 larvae in 2—3 drops of water. In a series of consecutive tests on material from one hatch we used the same portion of constant composition. The tests were carried out at a temperature of 22 and 25°. The duration of each test was 3 hours with half-hour exposition; the results of determinations were recalculated for 0° and normal pressure.

The following larval stages were studied: 1) before the beginning of blood circulation; 2) initial blood circulation in the head; beginning of larval motion; 3) appearance of blood circulation in the trunk; pigmentation of eyes; 4) implantation of segmental vessels in the dorsal fin; 5) strong development of segmental vessels in the dorsal fin with reduction of the ducts of Cuvier, ensuing upon the reduction of the yolk sac; 5) the formation of gills and air bladder; marked development of pectoral fins, with simultaneous inhibition of growth and appearance of a yellow pigment, the larva beginning freely to swim; 7) opening phase of gill breathing; the air bladder filling with air absorbed from the outside, the yolk externally almost completely disappearing, the larva soon beginning to starve.

The figures of oxygen consumption are given in Table 1 in the order of increase in the length of larvae. The figure shows the same data graphically represented by solid lines*. From average rates of O_2 consumption, taken at corresponding points of the curves, is calculated respiration per unit of dry weight**; results are shown in Table 2 and in the figure by dotted lines. Likewise is calculated respiration per unit of length, assuming a certain correlation to exist between the length of the larva and its breathing surface.

Table 1

Average length of larvae in mm	Stage	O_2 consumption per hour by 30 larvae at 22°		O_2 consumption per hour by 30 larvae at 25°	
		№ of lot	mm³ O_2	№ of lot	mm³ O_2
—	1. A short time before the beginning of blood circulation	1.I	4.8	10.I	5.3
2.54		6.I	4.7	—	—
—		6.I	5.1	—	—
—		3.II	6.3	—	—
—	2. Blood circulation in the head	1.I	5.8	8.I	6.2
—		4.I	6.0	—	—
3.12		6.I	6.7	—	—
3.17		3.II	7.7	—	—
3.45	3. Blood circulation in the trunk	—	—	11.II	8.3
3.64		7.II	7.5	—	—
3.73		—	—	12.II	9.1
4.09		6.I	7.8	—	—
—		4.I	8.2	—	—
4.10		2.I	7.8	—	—
4.27	4. Implantation of segmental vessels in the dorsal fin	—	—	11.II	10.3
4.30		—	—	9.II	11.2
4.37		—	—	10.I	10.2
4.47		7.II	10.0	—	—
4.51		—	—	9.I	11.2
4.64		—	—	12.II	12.2
4.68		6.I	9.5	—	—
4.75		2.I	9.0	mixed	10.9
4.82		—	—	mater.	—
4.87	5. Strong development of segmental vessels	7.II	11.6	—	—
4.91		—	—	9.I	10.6
4.91		—	—	9.I	11.3
5.00		6.I	10.4	10.I	11.0
5.03		—	—	11.II	10.3
5.11		—	—	10.I	12.3
—		4.I	10.6	—	—
5.12	6. Formation and development of gills and air bladder	—	—	11.II	8.2
5.16		—	—	9.II	9.8
5.20		6.I	8.3	13.II	10.3
5.25		5.II	11.4	—	—
5.29		7.II	14.9	displ.	15.5
5.50		—	—	11.II	12.5
5.52		6.I	10.6*	10.I	13.7
5.54		7.II	16.2**	13.II	12.4
5.58		6.I	14.3**	—	—
5.66	7. Initiation of gill breathing	7.II	17.2	11.II	16.2
5.66		—	—	9.II	19.6
5.66		—	—	9.I	19.1
5.74		7.II	17.1	10.I	18.3
5.74		2.I	10.7*	—	—
5.80		—	—	9.I	19.0
5.82		—	—	11.II	19.1
5.86		6.I	16.4	9.I	21.7
5.86		1.I	16.1	—	—
6.07		6.I	15.2	—	—
6.23		1.I	15.6	—	—

Note. * Appearance of a yellow pigment.
** Initiation of gill breathing.

* There is an apparent decrease in the rate of oxygen consumption in the hatch 2. I, due to relatively larger size of eggs and larvae; nature of the respiratory level varying with age is the same as in the others.

** Dry weight was determined on material fixed with 20% of formalin.

Table 2

Length of larvae in mm	Stage	O_2 consumption per hour by 30 larvae		Dry weight of 30 larvae in mg	O_2 consumption per mg dry weight without yolk, per hour/mm³	
		22°	25°		22°	25°
3.35	2—3	7.3	8.3	0.85	8.6	9.7
4.10	3	8.3	10.0	1.20	7.0	8.4
4.40	4	9.0	10.5	1.43	6.3	7.3
4.87	5	10.5	11.5	1.60	6.6	7.2
5.20	6	10.0	10.0	1.85	5.4	5.4
5.99	7	16.0	21.0	2.79	5.7	7.5

Table 3

Length of larvae in mm		Stage	O_2 consumption as related to length, mm³	
22°	25°		22°	25°
2.54	—	1	0.067	—
3.12—3.17	—	2	0.07	—
3.45—4.10	3.45—3.73	3	0.07	0.083
4.47—4.75	4.27—4.75	4	0.07	0.08
5.20—5.25	5.12—5.20	6	0.063	0.06
5.66—5.99	5.66—5.99	7	0.09	0.111

Tables and curves show that with increase of the length of larvae and development of the vascular system there is a slow rise in oxygen consumption, though some of the tests proved that during the early period of formation of the air bladder there was a lowering of the rate of gas exchange in the larvae. However, this fact requires checking. Larvae in more advanced stages with gills in process of development (stage 7) consume a greater amount of oxygen than in earlier stages. Upon establishment of gill respiration, the rate of oxygen consumption begins to fall, evidently, due to starvation. As related to length, average rates of oxygen consumption undergo slight changes at stages 1—5, decreasing at the beginning of stage 6 and increasing markedly at stage 7. Hence, one may assume that in general in the course of development of the larval vascular system oxygen consumption per surface unit is constant, while it increases with the development of gills. There is a different regularity observed for respiration as plotted against dry weight. Respiration gradually falls to a minimum during the stage of the gills and air bladder formation, while during the period of gill development up to the beginning of gill breathing it rises to about the same level as in the stages of the embedding of segmental vessels in the fin and their initial development. There are certain differences in the results obtained at 22° and 25°: a) respiration at stages 1—5 drops more rapidly at 25°, 2) greater intensity of respiration at stages 6—7 is more pronounced at 25°.

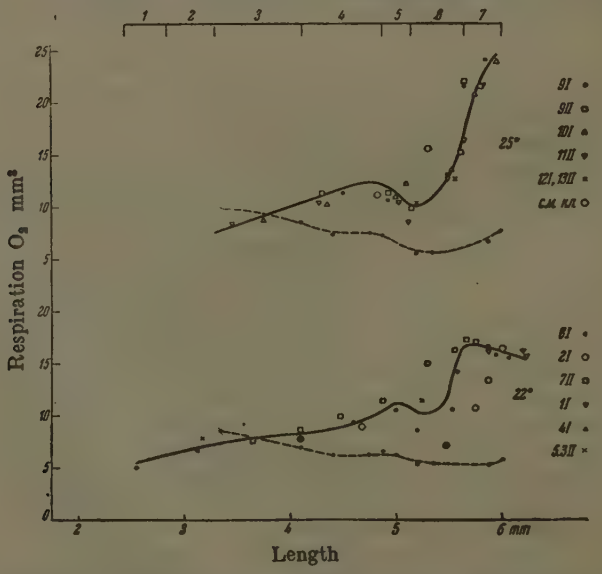
As pointed out by Babák ([18]), the rhythm of heart movements in larvae *Macropodus* is a factor regulating the rate of gaseous exchange under various conditions of the surroundings. It appears tenable that a relative change in the rhythm of heart beats is in some degree indicative of the extent, to which the development of the respiratory organs responds to the needs of the orga-

nism. Provisory data were obtained by counting the rhythm in larvae of the reserve portions of lots 6 and 7. Each time counts were made in 4 larvae from every lot. Four records were taken of the time required for 100 heart beats in each larva. The average data are given in Table 4.

Table 4

Date	№ of lot	Average length in mm	Stage	Pulsation rhythm per min.	Temperature during test	Ratios	
						pulsation rhythm to O_2 consumption	pulsation rhythm to respiration per mg dry weight
10.VIII	6	4.0	2—3	67	20.0	10.0	10.5
11.VIII		4.2	3	107	20.4	12.3	13.6
9.VIII	7	4.3	—	110	20.9	12.4	15.4
10—11.VIII		4.6—4.9	4—5	108—111	21.0	11.7	17.4
12—13.VIII	6	4.9—5.0	—	117—125	20.5	11.0	18.0—18.8
14.VIII		5.3	6	124	20.6	13.9	24.4
12.VIII	7	5.5	6	152	21.0	10.5	22.5
15.VIII	6	5.6	—	132	19.6	—	—
13—14.VIII	7	6.6	—	147—154	21.0	9.0	20.7
19—20.VIII	6	6.3	starvation	156	20.0	—	—

From average values of rhythm and respiration were calculated ratios of pulsation rhythm to the volume of oxygen absorbed and to respiration.



It appears that these ratios are rapidly increasing during the period of development of the function of Cuvierian ducts, slowly rising in the course of development of segmental vessels, showing an accelerated rate of increase about the time of appearance of gills, of air bladder, but decreasing during the time of development of gills. Thus, it is possible that insufficient develop-

ment of respiratory organs coincides with the period of development of Cuvier's canals, formation and initial development of gills.

Comparing the results of our observations, we may on the whole suggest one of the following interpretations. A certain stability of respiration and rhythm of heart beat during the period of considerable reduction of Cuvierian ducts (4.6—5 mm) is compensated for by the development of segmental vessels. As soon as the Cuvierian ducts have entirely, and the unpaired fins partly, lost their significance as respiratory organs, ensues the development of gills, again to some extent increasing the rate of respiration. At the same time, it may happen that the period of formation and development of gills in larvae of *Leucaspius delineatus* coincides with the most clearly pronounced effect of factors limiting respiration. Such an explanation would account for the temperature differences in our tests. Investigation of the relations existing between the phenomena described above and growth and differentiation should be the object of further studies.

Institute of Evolutionary Morphology.
Histogenetic Laboratory.
Academy of Sciences of the USSR.

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PALEONTOLOGY

FIRST REPRESENTATIVE OF SIBERIAN EARLY *TETRAPODA*

By J. A. EFREMOV

(Communicated by A. A. Borissiak, Member of the Academy, 20. II. 1939)

In spite of the presence in Siberia of immense areas of the Upper Permian continental deposits, not a single specimen of early *Tetrapoda*, which could be more or less definitely determined, was known from there until the very last time. The single pieces of bones obtained in the Kuznezk basin from Carboniferous (L. Ters river) and Upper Permian (Tomj river) deposits failed to contribute anything to the knowledge of the character of fauna of the vast Angarida. The possibilities of the presence in Siberia of terrestrial vertebrates were first discussed by myself in my work of 1937 *, in which the outstanding significance of the Tungus basin was pointed out.

In 1938 the imprint of a skeleton of a very small Stegocephalian, found among the remains of fishes, was placed at my disposal by Prof. L. S. Berg; these remains are from the Lower Tunguska river, and were obtained by the expedition of Arctic Institute of Northern Sea Route Administration.

V. P. Tebenkov, geologist of the Arctic Institute, reported the presence «on the left bank of the L. Tunguska river, at the river bend of 264 km, downward of the Ilimpbi river mouth (Amo-Tura region)», of a large new locality of fishes and Stegocephalians. «At the base of the slope, which is covered with trapp debris, is exposed a strata of green sandstones, interbedded with layers of red and brownish sheet-like sandstones. One of these brownish layers is filled with remains of Esterians, Ostracods, imprints of vegetation and fish remains».

According to preliminary determination, these deposits are forming the upper part of the Angara series (Tuffit strata of S. V. Obruchev), which is separated into an independent Korwuntchan series of Triassic age. E. M. Lutkevitch, who has been engaged in the study of Esterians, parallelized these beds with the Vetluga stage.

On the basis of examination of fish remains from this new locality, Prof. L. S. Berg referred the age of the fauna-bearing beds to be Upper Permian, or Low Triassic.

The single piece of rock, enclosing the remains of Stegocephalians, found among the remains of fishes (No 206/1 PIN), represents a small thin plate of fine-lamellate brown sandstone. This fine-granulate sandstone with dispersed particles of clay should be rather referred to siltstones. On the elastical material of sandstone there are observed unputrified particles of the eruptive basal rock. The texture of this rock presents an alternation of very thin (0.5 mm) layers of dark and light colours, of sandstone and clay origin respectively. The plate is split along one of the layers into two parts, bearing the positive and negative impressions of the Stegocephalian skeleton, surrounded by multiple Esteria shells. The osseous parts are preserved in the form of thin, extremely brittle, almost transparent film, enveloping the inner parts of bones, filled up with clay. Therefore,

* «The rôle of the Paleozoic continental basins of Siberia in the Paleontology of early *Tetrapoda*», Bull. of Ac. of Sc. of USSR, Biology department, 2 (1939).

all the attempts to prepare separate details have failed. Total length of the skeleton—37 mm. The skeleton is open from the ventral side.

The following parts of the skeleton are preserved: skull, vertebral column (almost complete), the left fore leg and part of the left hind leg. In addition to this, the external gills are preserved, and the soft parts of the body in the form of carbonaceous mass (figure). The skull of parabolic shape, broad, with very large orbits placed nearer to the front. Its right outside border is destroyed. The left mandible is preserved in situ. The orbits are bordered from inside with an annular collar of carbonaceous matter. In the left orbit a part of sclerotical ring, composed by square scales, is preserved. Three such scales are found also in the right orbit. The mandibular condyles are located forward of the occiput articulation line. The bones of the ventral surface of skull are considerably damaged, destroyed and intermingled with the skull roof bones. Only a massive parasphenoideum with very broad processus cultriformis is clearly discernible. The body of parasphenoid in its back portion is greatly dilated and evenly rounded. Pterygoid with long, narrow anterior and short, enlarged posterior (ramus posterior) branches, with transversely broadened basal part articulated with the antero-lateral angle of corpus parasphenoidei, is but hardly discernible. All the rest of the ventral side bones are undistinguishable.

Tungussogyrinus bergi gen. et sp. nov. Positive impression of skeleton, ventral side. Scale 3.

In front of the left orbit a rather large, poorly preserved tooth is found. Another, similar tooth is seen on the positive imprint, on the left side, a little bit forward of the skull.

The teeth of bluntly-conical shape, thin-walled, with large pulp, remind one very much of the teeth of *Branchiosaurus amblystomus* Credner.

Behind the caudal border of corpus parasphenoidei a few small pieces of bones, apparently belonging to the destroyed compressed occiput, are seen. These pieces of occiput are adjoined from behind by two broad shaft-like formations of semi-annular form. These formations considerably exceed in width the subsequent vertebrae, and show no smooth osseous film on their surface, as all the other bones do, which makes determination of their nature rather difficult. As these semi-annular formations are situated line-on-line with the whole of the vertebral column, probably, they represent the neural arches, placed at 180° with respect to the skull. But they so greatly exceed in the width and massiveness the neighbouring, directly following them vertebrae, that the above interpretation cannot be taken as incontestable. The cartilaginous nature of these semi-annular formations is definitely indicated by the character of their fossilization, without any traces of osseous matter preserved, only the general outlines of the destroyed cartilage, entirely replaced by the matrix, being retained. Possibly, these semi-annular formations are the remains of some cartilaginous building, which in the lifetime of animal supported the gorge region.

The vertebral column appears from under these semi-annular formations; further on, the whole length of the vertebrae column is exposed. The vertebrae are lying on their side, and locally damaged to a considerable extent. The total number of vertebrae, discernible on the imprint, is 20. To this number not less than 3 vertebrae should be added; these ought to be located under the shaft-like formations in the posterior portion of the skull. Even this cannot be considered as complete number of vertebrae of the adult individual, since that part of the tail, which in the available specimen is not yet ossified, should be composed by quite a number of vertebrae. The vertebrae have solid elongated centers and rather thick neural arches with well developed transverse and spinous processes. The poor ossification of vertebrae does not allow to study the correlation of centers with neural arches and to determine the type of their structure. In any case, in view

of the monolitic centers, these vertebrae can be referred neither to the embolomerous, nor to the rachitomous type. No traces of ossified costae and of shoulder girdle is observed.

The left anterior leg consists of rather long humerus with dilated ends, comparatively short radius and ulna, having the form of rounded rods, and four elements of metacarpus, one of which is greatly damaged. The phalanges and elements of carpus are not preserved, as, to all evidence, they have not yet been ossified. Of all the mentioned bones, naturally, only the ossified diaphyses are preserved.

Of the pelvic girdle, only ilium, which has already been sufficiently ossified, is preserved (also on the left side). The lower part of ilium, as seen on the imprint, is destroyed, only the process of its upper part extended forward being completely preserved. This comparatively very long process is slightly bent. The destroyed lower part of ilium is almost directly adjoined by femur, the upper part of which is also broken off. It is about as long as humerus, its lower part being dilated, the upper one narrowed. Here also, only the middle of bone is ossified. Assuming that ilium is found in its correct initial position, the number of praesacral vertebrae should be 17—18, and about as many vertebrae should compose the tail of the animal.

The preservation of the soft parts of the body, in the form of fat carbonaceous matter, distinctly visible on the imprint, is a rather rare phenomenon. Behind the skull, the external gills are preserved in the form of narrow black bands, three on each side; apparently, they derive from a common stem.

The gills on the left side are approximated and directed forward; on the right side they are diverging, the foremost gill being turned under the occipital margin of the skull.

The specimen under description is the first specimen found, on which the shape and number of external gills in the Stegocephalian larvae can be studied. The thickest layer of carbonaceous matter, scaling from above in the form of separating thick round scales of various dimensions, is observed in the middle part of the body. These scales are, probably, the remnants of the rudimental ventral armour.

In the posterior part of body, its outlines, as well as the outlines of the leg stem, are rather exactly reproduced on the carbonaceous imprint, even the skin folds corresponding to the bend of the body being shown.

The minute dimensions of the animal under consideration, the presence of external gills and poor ossification of the skeleton definitely indicate that here we have to deal with an Amphibian larva. Basing on the character of the structure of the skull with continuous roof of dermal bones, we can safely determine the larva under consideration as belonging to Stegocephalians.

As far as the type of vertebrae structure in our larva is not definitely established, it is difficult to determine to which particular group of Stegocephalians it should be referred. The vertebrae, as described above, can equally belong to the representatives of *Phyllospondyli* group, as well as to *Lepospondyli*, or even *Stereospondyli.*

Of all the known forms of Stegocephalians the animal under consideration most closely resembles the representatives of the *Branchiosauridae* family of *Phyllospondyli.*

All the known details of the structure of vertebrae, skull and teeth are very much similar to those in the typical representatives of Branchiosaurians (*Branchiosaurus*, *Pelosaurus*, *Melanerpeton*). However, the Branchiosaurians were also studied mostly as larval specimens, and it appears quite possible that a number of typical characters of their structure is peculiar only to the larval stage of their existence (except the parabolic form of the skull). Therefore, the possibility is not excluded that our animal does not belong within this ancient group, and may prove to be the larva of one of the latest Stereospondylous Labyrinthodonts, characterized by a parabolic skull, namely, to the *Brachyopidae* group (*Dvinosaurus* inclusive). However, a number of characters testifies against this assumption.

Even the smallest larvae of all the Phyllospondylous and of many Lepospondylous Stegocephalians are characterized by their mandibular condyles being located anteriorly, which is observed in the specimen under description. In all the studied larvae of Triassic Labyrinthodonts articulationes mandibuli are located more posteriorly than in the adult individuals of the same

forms. The *Phyllospondyli* and *Lepospondyli* left the Labyrinthodonts far behind on the common path of evolutionary development of Stegocephalians, and as early as in Carboniferous acquired rather light skull with articulatio mandibuli located anteriorly, while most Labyrinthodonts attained this stage only in Triassic. Articulationes mandibuli in the larva under consideration are placed much farther anteriorly than in anyone of the adult specimens of Triassic Brachyopids. The vertebrae of the highly developed Stereospondylous Labyrinthodonts have shortened centers, the rate of their ossification in larval stage being quite inconsiderable. The center is separated from the neural arch by a wide cartilaginous space. The long vertebral centers of the form under consideration, closely adjoining the neural arches, indicate a more ancient type of structure of its vertebral column.

Finally, the presence of long process in the upper portion of ilium is a character peculiar to early Stegocephalians, which is never observed in highly developed Labyrinthodonts. Therefore I am inclined to regard our Tungus specimen as the larva of a Stegocephalian belonging to the *Phyllospondyli* or *Lepospondyli* group, but not to the Labyrinthodonts. By the general character of the skeleton and skull structure, the Tungus specimen is most closely related to the *Phyllospondyli*, namely, to the *Branchiosauridae* family. However, the character of structure of its parasphenoid with very broad processus cultriformis and caudally bent corpus parasphenoidei greatly differs from those in all the known forms of Branchiosaurians. By this characters the larva in question should be referred to a new form of Branchiosaurians. Although the adult specimens of such a form are not known, I think it reasonable to separate this unique specimen into a special genus and species, for which I suggest the name of *Tungussogyrinus bergi* gen. et sp. nov. The specific name is in honour of Prof. L. S. Berg, who has greatly contributed to the knowledge of Siberian fauna of Paleozoic fishes.

D i a g n o s i s. Stegocephalian with broad parabolic skull. The large orbits located anteriorly are bound with sclerotical ring. The mandibular condyles shifted anteriorly. Parasphenoid with large processus cultriformis and broad, caudally bent corpus parasphenoidei. The teeth are bluntly-conical, thin-walled. Vertebrae with elongated solid centers; the number of praesacral vertebrae is equal to 17—18. Ilium in its upper part sends off a long process. Ventral armour, apparently, is composed by round scales. The larva has external gills, three on each side.

The embedding conditions of the *Tungussogyrinus* remains are very much similar to the conditions of life of the Amphibian larvae. The *Tungussogyrinus* inhabited a large fresh-water pool or small lake in marshland. The abundant remains of fishes, Estherians and Ostracods point to the concentration there of a large number of living creatures at a period that preceded their mass death. To all appearance, this water basin, formed at the period of overflow, existed for but a short time, then rapidly diminished in size and dried, or was blocked up with sand. Similar phenomena of drying up of the temporary water basins, formed in valleys at the period of river overflow, and abounding with fishes and other fresh-water animals, can be observed in our time as well.

After death the *Tungussogyrinus* larva was subjected to the effect of maceration, which resulted in mollification of the soft parts of the body; this can be inferred from the position of gills and dislocation of the whole mass of body to one side of the vertebral column.

The age of *Tungussogyrinus* cannot be definitely determined by a single specimen, which offers no possibilities for its thorough study.

If our *Tungussogyrinus* is really the larva of a Branchiosaur, or Lepospondyl, the determination of age of the Lower Tunguska locality's beds, made by other investigators, should be rejected.

The *Branchiosauria* and *Lepospondyli* are known only from the Upper Carboniferous and basal layers of the Lower Permian; and in the latter case,

the Permian age of horizons, bearing the Stegocephalian fauna, is as yet a matter for dispute.

Assuming the possibility of eastward migration of the Stegocephalian fauna (from Europe to Angarida), we must admit the more recent age of our specimen, corresponding approximately to that of the upper layers of Lower Permian (Kungur series). The determination of the *Tungussogyrinus* age as Triassic must be rejected.

The finding of the *Tungussogyrinus* specimen is a fact of especial significance, as it indicates that in Upper Paleozoic Era the Tungus basin was inhabited by fauna of terrestrial vertebrates. Properly organized thorough investigations of this region will, certainly, result in the exploration of a number of new localities, which will open up vast perspectives for the study of evolutionary development of the early terrestrial vertebrates, and for drawing up the exact stratigraphy of continental strata of Siberia Upper Paleozoic.

Paleontological Institute.
Academy of Sciences of the USSR.

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NEW *CRICETIDAE (GLIRES, MAMMALIA)* FROM THE OLIGOCENE OF MIDDLE ASIA

By A. I. ARGYROPULO

(Communicated by A. A. Borissiak, Member of the Academy, 26. II. 1939)

The family *Cricetidae* rather richly represented in the Tertiary deposits of Western Europe, partly of Eastern Asia and America, was known until quite recently but from the Quaternary of the USSR, where it is represented by recent species. In 1938 (1) were for the first time described hamsters from the Miocene of Caucasus (Bielomechetskaya) and Oligocene of Kazakhstan (Myn-sai). *Cricetodon caucasicus* Arg., from the former locality, is a typical member of the more modified species *Cricetodon* (united in the subgenus *Palaeocricetus* Arg.), widely spread in Western Europe in the middle of Miocene and Oligocene. The described *Cricetops affinis* Arg. from Kazakhstan is very close to the Oligocene Mongolian *Cr. dormitor* Matt. et Granger. The community of Mongolian and Middle Asiatic fauna of rodents, still exemplified by a number of contemporaneous forms, had already been existing in ancient times [cf. also *Prosciurus* sp. (2)].

Recently we discovered in the Upper Oligocene of the Aral plain hamster-like rodents which are be placed next to the genus *Schaubeumys* Wood (*Sch. aralensis* Arg. and *Sch. woodi* Arg.), hitherto known but from the Miocene of America. Supplementary material on these species should be studied; they may, possibly, prove to be representatives of a separate genus, but undoubtedly of the group *Eumys* (including *Schaubeumys* as well) widespread in the Middle Tertiary deposits of America. The ancient kinship between the fauna of rodents of Asia and America has been now established in relation to numerous Oligocene forms (*Desmatolagus*, *Ardynomus*, *Eumys*, *Prosciurus*), and in some cases even full identity of genera may be admitted.

The present communication contains a description of two new genera of hamster-like rodents from the Oligocene of the Aral plain. The find is of great interest, for if in regard to fossil species *Cricetidae*, hitherto known from the USSR, we could point out, and with sufficient clearness, their nearest kinship, the taxonomic position of *Eumysodon* gen. n. and *Aralomys* gen. n. is so far entirely unclear to us. Thus, we may speak about the discovery of «endemic» features in the Oligocene fauna *Cricetidae* of Middle Asia.

All these data, though fragmentary as yet, present valuable material for the elucidation of the development and origin of the Asiatic fauna. Special attention should be given to further collection of material from earlier Tertiary deposits in the USSR, particularly in Siberia and Middle Asia.

Eumysodon gen. n. (for *Eum. spurius* sp. n.)—a relatively big rodent with lower series of molars about 7 mm in length. Structure of lower molars, somewhat recalling that in *Cricetops*, in a way that in *Eumys*, is however more simplified, while bearing many peculiar features. M_1 (inf.) with cingulum anterior well developed but narrow, rather extensive branch of protoconid and distinct mesostylid heel. The latter is now present now absent on M^2, and lacking on M^3. Thus, the 1st molar in *Eumysodon* retains structural features primitive for *Cricetidae*. All the cusps on molars are relatively small, low, slightly elongate, their connecting ridges being relatively long. The valleys between tubercles on the lingual side are but slightly deeper than on the external side. There is a negligible difference in the size, and partly in the pattern of the cusps on the lingual and labial side of the tooth. As usually, cingulum posterior has but one labial branch running directly from the hypoconid (thus, this element may be regarded as the posterior branch of the hypoconid), a very large one, on the whole equal in size to the entoconid. Likewise, cingulum posterior is strongly developed in *Schaubeumys*, *Eumys* and evidently in *Aralomys* as opposed to *Cricetops*, in which it is lacking on M^3 and is narrow and divided in two branches on M_1 and M_2. The latter molar is not expanded in the anterior region, the lateral edges of the crown being nearly parallel. All molars are about equal in length. Of the upper series of molars but M^2 is known. It exhibits a fully developed posterior branch of the protoconid, a narrow cingulum anterior in the shape of a rim, and a large cingulum posterior labiale, like in the lower jaw. Molars with two fused roots. The anterior root of M_1 and posterior of M_3 are rather inclined. On M_2 between two large roots there would be space for an additional small one.

As may be seen from the foregoing diagnosis, *Eumysodon* displays a rather peculiar pattern of the grinding surface of the lower molars, in general less simplified than in Oligocene *Cricetodon*, but more complex than in the Upper Tertiary *Palaeocricetus*. It differs from *Eumys* mainly by the absence of the pseudo-ledge of the mesostylid. As to the relationship between the new genus and the Mongolian and Chinese *Sinocricetus*, *Nannocricetus*, *Anatolomys* and others, it should be noted that these diminutive hamster-like rodents have many features in common with the recent genera and have, for the most part, lost the characteristic vestiges of the earlier groups, i. e. vestiges still persisting in *Eumysodon*.

We hope to be able to give a detailed account of the relations of *Eumysodon* and *Aralomys* described below to other Tertiary hamsters in the near future, in the course of a more exhaustive description of the remarkable Oligocene fauna of rodents of the Aral plain.

Eumysodon spurius sp. n., № 210-3, fragment of mandibulae sin., with complete set of molars; belonging to a fully mature animal with a rather worn surface of molars. Specimen from the collection of the Paleontological Institute of the Academy of Sciences of the USSR.

Horizon. Upper Oligocene. Agyspe on the northern shore of the Perovsky bay, Aral sea, Kazakhstan. Remains enclosed in green clay underlying clay with marly concretions (3). We have previously (2) made a brief report about the rest of rodents found in that hozizon. As to other vertebrata, there have been, according to J. A. Orlov (3), met: a giant rhinoceros closely related to *Indricotherium* (*Aralotherium* Borissiak), then rhinoceroses of average size, small even-toed ungulates, a large wild cat, and of birds—a representative of *Anseriformes*.

Description. Length of the tooth row (measured upon the crowns)—7.1 mm. Length—width of M_1—2.4×1.9; M_2—2.3×2.05; M_3—2.4×1.9. M_1 (inf.) metaconid bunoid, united to cingulum anterior, lying like a narrow

rim on the anterior edge of the crown. Protoconid with well developed, but short posterior branch. Median crest («Längsgrat») with distinct mesostylid heel. Hypoconid small, bunoid, fused with a very large cingulum anterior, forming a second cuspule on the posterior edge of the tooth.

M_2 (inf.). Cingulum anterior like a narrow rim. Protoconid and hypoconid bunoid, metaconid and entoconid greatly stretched. Distinct short branch of protoconid. Structure of cingulum posterior like that on M_1.

M_3 (inf.). In general outline this molar is like M_2, but slightly more stretched on the longitudinal axis. Position and size of elements identical with those of second molar, except that protoconid has no posterior branch. Metaconid bears on its posterior wall a characteristic small heel (Fig. 1, *b*), the larger portion of which lies beyond the abrasion surface, in the shape of a rod on the slanting lateral surface of the metaconid. A similar rod on the metaconid exhibit also M_2 (inf.) in *Eumysodon orlovi*, however, it is less strongly developed. We do not know of structures of the kind described in any other representatives of *Cricetidae* (s. lato).

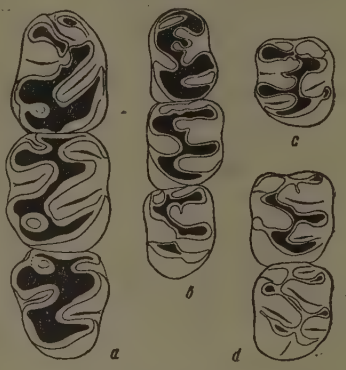

Fig. 1. *a*—*Aralomys gigas* gen. et sp. n., M_1—M^2 inf. dext. (№ 210-7); *b*—*Eumysodon spurius* gen. et sp. n., M_1—M_3 inf. sin. (№ 210-3); *c*—*Eum. orlovi* sp. n., M^2 sup. dext. (№ 210-6); *d*—*Eum. orlovi* sp. n., M_2—M_3 inf. sin. (№ 210-4).

Foramen mentale is lying at the level of the anterior edge of M_1, 5.1 mm below the outer edge of mandibulae. Crista masseterica becomes indiscernible reaching the median line of M_2.

Eumysodon orlovi sp. n., № 210-4, fragment of mandibulae sin. with M_2—M_3 (teeth slightly worn); № 210-5, with same (teeth very strongly abraded); № 210-6, M^2 (sup. dext.). Specimen in the collection of the Paleontological Institute of the Academy o Sciences of the USSR.

Horizon—see the one above.

Description. Differs from *Eum. spurius* by greater size and details of pattern of the grinding surface of molars. Length of $M_2+M_3=5$—5.2 mm; in *Eum. spurius* length of $M_2+M_3=4.5$ mm. Length—width: M_2 (inf.) 2.7×2.1; M_3 (inf.) $2.3-2.4 \times 2.1$; M_2 (sup.) 2.6×2.2 mm. As distinguished from *Eum. spurius*, the posterior branch of protoconid on M_2 is lacking. It is very characteristic that on the edge of the crown in M_2 (in the upper as well as in the lower jaw) there is observed a small cuspule united to the hypoconid or the posterior internal tubercle; on M_2 (sup.) this cuspule has a dentine islet.

M_2 (sup.), tentatively assigned by us to the described species, exhibits a well developed branch of the protoconid, in all other features showing much likeness to M_2 (inf.) in *Eum. spurius*.

Height of mandibulae behind M_3—6.2 mm. Crista masseterica becomes indiscernible at the level of M_1.

Aralomys gigas gen. et sp. n., № 210-7, fragment of mandibulae dext. with a complete row of molars. Type in the collection of the Paleontological Institute of the Academy of Sciences of the USSR.

Horizon—see the one above.

Description. A large hamster-like rodent, exceeding in length even representatives of *Cricetops* Matt. et Grange. M_1 (inf.) length—3.8,

breadth — 3 mm; M_2 (inf.) length — 3.8, breadth — 3.3 mm; M_3 (inf.) length —3.5, breadth—3 mm. $M_1 - M_3$ (inf.) — 11.1 mm.

Pattern of molars rather simplified; no branches springing from paraconid and hypoconid, no trace of mesostylid heel either. In front of the metaconid there is an accessory cuspule. Metaconid, separated from hypoconid till old age, is very narrow and stretched on all the molars, as contrasted with the small rounded entoconid. Cingulum anterior on M_2 and M_3 well developed, with a large labial branch; M_1 shorter than M_2; M_3 constricted in the posterior region. The roots of the molars are like those in *Eumysodon spurius*.

M_1 (inf.) relatively very much shortened, slightly narrowing in the anterior half.

Metaconid lies isolated, notwithstanding strong abrasion of molars, and is relatively very small. Anterior and labialwards from metaconid, on the border of the crown, is placed a well developed cusp with dentine islet and small branch running toward the paraconid. Entoconid large. Paraconid with rudiment of posterior branch, rather minute. Hypoconid greatly stretched.

M_2 (inf.). Well developed cingulum anterior with a long labial branch. Hypoconid narrow and elongate.

Width of mandibulae from crista masseterica to the upper border of the inner side (along the line between M_2—M_3)—8 mm.

Zoological Institute.
Academy of Sciences of the USSR.
Leningrad.

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PALEONTOLOGY

BOTHRIOLEPIS TURANICA n. sp. FROM WESTERN TIAN-SHAN

By D. OBRUCHEV

(Communicated by A. A. Borissiak, Member of the Academy, 2.II.1939)

In 1935 A. A. Denisyuk found a specimen of *Bothriolepis* in the Tashkent region, in unfossiliferous sandstones called usually «Subdevonian quartzites and schists». This is a new and distant area for Devonian fishes, thus the specimen deserves special description.

Locality: Zaktan-say, right tributary of the Kok-su, discharging itself in Chatkal River 1.5 km downstream of Brich-Mulla (80 km NE from Tashkent). Outcrop 1258.

Section, according to Denisyuk, is the following, from below upwards

1. Tuffs and tuffaceous sandstones with clay interbeds. Thickness in the outcrop	50—60 m
2. Coarse grained gray and black sandstones, strongly pyritized	300 »
3. Violet tuffaceous sandstones	25 »
4. Bright, fine grained sandstones, slightly pyritized	75 »
5. Violet tuffaceous shales and sandstones, distinctly bedded. *Bothriolepis*	80 »
6. Bright and yellow marly and argillaceous shales with NaCl-pseudomorphoses and ripple-marks	75 »
7. Black thick bedded fossiliferous limestones; *Spirifer verneuili* Murch., *Productus* sp. (cf. *vlangalii* Rom.), *Camarotoechia pleurodon* Phill., *C. deprati* Mansuy, *C. livonica* Buch, *C. boloniensis* Orb., *C. turanica* Rom., *Reticularia sp.*	

Age: Upper Devonian, Frasnian stage.

Facies: from the short description of the section we can conclude that *Bothriolepis turanica*, like many other species of this genus, was not embedded in a normal marine sediment, but in deposits of a shallow basin separated from the sea. Later, an ingression of marine fauna took place. We must remember, however, that *Bothriolepis* could have lived far from its embedding place, e. g. in a river discharging here.

Holotype: right mixilateral, Paleontological Institute of the Academy of Sciences, Moscow, № 178—1 (Fig. 1).

Definition: a rather small species. Body carapace deep, with highly arched dorsal plates. Mixilateral ornamented with a network of nodose ridges, radiating from the ossification centre; area overlapped by posterior median-dorsal very short.

Description and Comparison: the unique specimen is a right mixilateral. Its prominent feature is the great angle between the dorsal and the lateral laminae, attaining 145°, while in *B. panderi* it measures only 110—120°. In the majority of known species, e. g. in *B. canadensis* [(6), Fig. 29], this angle is not much greater than a right one. When compared with the transverse section of the body carapace of these species, the

mixilateral of *B. turanica* suggests a deep body carapace, in which the two median dorsal plates formed a rather high ridge. In this respect the new species differs from the common forms of *Bothriolepis*, being more like *Pterichthys*. Among the known species of *Bothriolepis*, in *B. cristata* Traq. [(7), Pl. 31, Fig. 2] the angle between the dorsal and the lateral laminae of the mixilateral is greater than in more typical species, as can be deduced from the picture. This angle is equally great as in the species under description, in two mixilaterals figured by E. S. Hills—*B. gippslandiensis* Hills from Victoria[(3), p. 221, Pl. 11, Fig. 3], and *Bothriolepis* sp. from New South Wales[(4), Pl. 56, Fig. 8].

A nearly vertical hind border of the mixilateral is also a feature common both for *B. turanica* and the Australian forms. In other species it is strongly levelled. This feature suggests a rather short posterior median-ventral in these forms. This plate must have been particularly short in *B. turanica*, in which the corresponding overlapped area on the mixilateral is unusually short. This latter feature distinguishes the new species from the similar Australian forms.

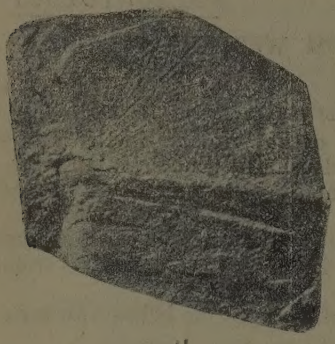

Fig. 1. Right mixilateral of *Bothriolepis turanica* n. sp., enlarged twice.

The typical features of the genus are normally developed in our specimen—the dorsal pit-line and the pattern of the ornamentation. The radiating nodose ridges, especially in the angle between the lateral and the pit-line, seem to be a characteristic feature of the new species.

Dimensions. Length along dorsolateral ridge—23 mm; maximum width—23 mm; length of posterior dorsal border—13 mm; length of anterior dorsal border—12 mm; length of posterior border—17 mm.

Distribution of the Genus *Bothriolepis*. Stensiö's table illustrating the distribution of Antiarchi [(6), p. 26] and Gross' reviews[(1), p.58;(2),p. 23] must be now completed, as regards *Bothriolepis*. This genus appears at the very base of the Upper Devonian, and does mostly not persist till the end of that epoch. It occurs in the Baltic states, Belgium, England, Scotland, East Greenland, Ellesmere Land, East Canada, Eastern and Western States, Victoria Land, and Australia. In the Soviet Union the genus has been found in many localities in the Leningrad district, on Timan, in Minusinsk region, and near Tashkent.

We must point out the resemblance of our new species to the Australian forms. This discovery suggests the possibility of a connexion occurring here between the two areas of Devonian fishes—the north and the south ones. Farther south-eastwards one more locality has been noted by Mansuy[(5), p. 62] in Indo-China. According to Mansuy, there have been found badly preserved remains reminding one of *Asterolepis* and *Homostius*. Discoveries of further localities in Asia must be expected.

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Academy of Sciences of the USSR.
Moscow.

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